JAN 16 PERIODICAL DEPT.

SCIENTIFIC AMERICAN SUPPLEMENT

Copyright, 1919, by Scientific American Publishing Co.

VOLUME LXXXVIII] NUMBER 2291 ★ NEW YORK, DECEMBER 20, 1919 ★ [10 CENTS A COPY $5.00 A YEAR

Published weekly. Entered as second class matter December 15, 1887, at the Post Office at New York, N. Y., under Act of March 3, 1879

Copyrighted by Japan Press Illustration Co.

IRON AND STEEL MANUFACTURE IN JAPAN—BOYS FILLING RESISTANCE-COIL MOLDS—(See page 368)

The Sense of Direction in Animals

General Principles Analyzed and Systematized

By Dr. Rudolf Brun, Assistant in the Neurological Polyclinic of the University of Zurich

Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from the *Biologisches Centralblatt* (Leipzig).

The problem of orientation in space is of no small interest from a psycho-physiologic and clinical point of view in human beings. I will merely refer, in passing, on the one hand, to the astounding capacities of orientation possessed by certain savages, according to the reports of numerous travellers, and on the other hand to those remarkable and serious disturbances in the faculty of orientation, which the neurologist so often has the opportunity of observing in patients suffering from cortical blindness and so-called psychological blindness. In human beings, however, this question is naturally one of extreme complexity; only very recently has this problem been seriously attacked and this is likewise true[1] with respect to young infants, and for this reason it is still rather obscure even as regards the distribution of its essential components. However, an experimental analysis of the far simpler conditions present in the lower organisms such as birds and insects, may at least vouchsafe us a general insight into the principles according to which the complicated mechanism of distance orientation develops, and may likewise yield valuable data upon which to base future inquiries. When one examines the extensive literature dealing with this question one is often greatly surprised to see how arbtrarily many authorities, who are otherwise strictly scientific, express opinions based on mere theory, in spite of their careful and lucid observations. They display an arbitrariness, indeed, which frequently does not shrink from purely romantic and physiologically incomprehensible hypotheses, themselves based upon earlier untenable theories. For example, there is the theory of mysterious, still undiscovered powers (Fabre, Bethe); of an "absolute, internal power of direction entirely independent from all sense impressions of the external world" (Cornetz), or of an absolute knowledge of the four cardinal points of space (Berthelot); or of a perception of the magnetism of the earth (Viguier) or of "infra-luminous rays" (Duchatel); or of "nasal sense" (Cyon); or of a detailed kinesthetic registration of all the twists and turns executed by the body on the trip out (Bonnier-Raynaud-Pieron); or of a polarization of the chemical particles concerned in the sense of odor (Bethe). All these and many other mysterious capacities have been proposed as "explanations" of the sense of direction exhibited by carrier pigeons, bees, and ants. In my opinion the cause of all these scientific misconcepts is to be looked for in a certain lack of the possession of a general biological point of view. There has been a lack of a solid theoretical basis which might have made possible a unified view of the phenomena of orientation in general, of their various biological stages, and of the general psycho-physiological laws which govern them. I have attempted to outline such a theoretical basis in my monograph upon Space Orientation in Ants[2] and the points of view thus obtained have proved to be both practical and fruitful of results in my special experimental inquiries. I propose, therefore, to set forth in this first address the general bases of observation before describing in a second lecture the results of my experiments with ants . . . believing that such a theoretical outline will be of considerable assistance in the comprehension of the experiments referred to, which were often quite complicatd in character.

1. SPACE ORIENTATION IN GENERAL.

Orientation in space may be defined in general as the capacity possessed by an organism to place its body or the parts thereof in a definite position with respect to the stimuli affecting it, or, to relate its progress in space in some regular manner to the stimuli concerned. According to this general definition the capacity of orientation in all organisms including those which are sessile must be regarded as a primary property of living protoplasm and as such connected with every primary response to a stimulus.

If we attempt to group the manifold phenomena here concerned according to biological and physiological laws, we may place them to begin with in two chief categories: I. A proprio-ceptive or absolute orientation; and II. An extero-ceptive or relative orientation.

[1] Systematic investigations with respect to the kinesthetic sense of direction in human beings have recently been made by Szymanski (Pflueger's Arch. f.d. ges. Phys. 1913).

[2] Brun, The Orientation in Space of Ants and the Problem of Orientation in General. Gustav Fischer, Jena, 1914.

I. The proprio-ceptive orientation is derived exclusively from internal sources, i.e., from passive or active movements due to stimuli which have their source in the parts of the body which are moved. On this acount it bears no close relation to the external world, but merely orients the organism with regard to its absolute position in surrounding space or else with regard to the position of its members with respect to each other . . .

The proprio-ceptive orientation is static or dynamic according to whether its purpose is satisfied by the simple response to the primary "position stimuli" or whether the result of these primary responsive movements is concerned in the development of a new and secondary orientation.

1. Static orientation is concerned with a simple placing of the organism or its parts in a definite relation to the perpendicular direction of gravity. In the case of plants these movements are extremely slow; they are obviously dependent upon a polar dissimilarity in the intensity of growth in the cells affected by the given stimulus, and thus they gradually lead to arrangements in the growth of the plant known as axotropisms (geo-tropism, helio-tropism, etc.) This most primitive form of orientation in space may be termed plasmo-static orientation and offers a contrast to the neuro-static orientation of animals in which the position movements follow promptly and with the most delicate adjustment the alterations constantly taking place in the equilibrium of the body by means of complicated statotonic sense apparatus and reflex apparatus.

EDITORIAL NOTE.—*This valuable article, which is of equal interest to the scientist and the layman, is the report of a lecture given by the author in the Psychiatric-Neurological Society of Zurich, the first portion being delivered December 12th, 1914, and the second portion January 23rd, 1915. It is an admirable example of clear thinking based on known facts in contrast to the too common practice among certain scientific men of deriving far reaching conclusions from purely hypothetical premises.*

2. Dynamic proprio-ceptive orientation is composed of a more or less complicated time succession of those secondary proprio-ceptive registrations which we are accustomed to call kinesthetic, using the word in its widest sense.

The stato-lithic, the lateral organs and semicircular canals of the labyrinth show passive alerations in the position of the axis of the body even when all other kinesthetic and extero-ceptive signs are excluded. That this is true is proved by the interesting fact that deaf mutes under water (in which case the muscular-static sense is excluded or at any rate greatly reduced) very often lose all sense of orientation with regard to the absolute position of their body in space and do not even know which is up and which is down. The function of static apparatus may be included with the muscular static sense (together with the corresponding passive perceptions of tension in the sinews, joints, and skin) under the designation *passive sense of position*, or *passive kinesthesia*. In contrast to this, active kinesthesia, the muscular sense, better termed the "sense of motion" operates pretty exactly to produce orientation by means of the active degrees of contraction ocurring from time to time in the different groups of muscles and also by the synergias and successions employed in acomplishing certain kinetic figures, such for example as a quarter turn to the right. As bares thesia, i. e., the sense of weight or force, it also registers roughly the active increase of muscular resistance which is required in mountain climbing to overcome gravity and in the descent of mountains for retarding the rate of passive fall, and thus it makes possible a certain estimation of the angle of inclination. And finally, it is quite conceivable that even from the length of the road which has been passed over a certain impression may arise that the intensity of the degree of fatigue is somehow proportional to the length of the journey. From this point of view we are quite justified, therefore, in speaking of a "sense of fatigue" or, in consideration of its function, of a "distance sense" or a "pedometer sense".

The importance of all these kinesthetic sensations with respect to orientation in space is generally much under-estimated; we are accustomed to class them among the so-called "obscure sensations" which are incapable of arousing definite associated ideas. This is a mistake, however, for the most ordinary every day observation teaches us that these complex sensations leave behind them, under certain conditions, very definite kinesthetic "engram successions"[3] [the word engram signifies in brief a hereditary tendency] which, in combination with extero-ceptive sense impressions, and *only* with these, are of the greatest significance with respect to locomotor orientation in space. Everyone knows from his own experience, for example, with what certainty one makes the required twists and turns in going, for instance, from the bed to the wash-stand, or to the door of a room. But in this case the sense of touch has previously taught us the relative position of the bed, and starting from these extero-ceptive guiding points we undertake without fear the accustomed kinesthetic journey in the dark, which in a strange hotel room would naturally take us to entirely different places. The kinesthetic engram successions are far more delicately developed in the case of a blind person, which is probably why these persons display such astonishing certainty of movement within areas known to them and even on the streets of the towns where they live.

II. While the proprio-ceptive orientation is concerned merely with the position and movement of the body, in what we may call an "absolute" space, *the extero-ceptive senses* orient the organism *relatively*, i.e., they place it in a definite relation to certain definite points in the external world. The required preliminary to this end is naturally a more or less sharp sense localization of the stimulus concerned, or in other words the providing of the sense concerned with signs of locality. Extero-ceptive orientation in space implies, therefore, the definite localizing of extero-ceptive stimuli upon the receptive sense organ.

An example will make this clear. In human beings the sense of smell is not concerned in exact orientation in space, purely and simply for the reason that the receptive sense organ, i.e., the mucous membrane of the nose, is buried inside the skull and, therefore, does not separate spacially the various odors proceeding from different objects, but receives them all together in a diffused mixture. It is quite otherwise with ants. In this case the pallillæ of smell are distributed upon symmetrical and highly movable organs—the antennæ. With these "movable noses" as Forel has admirably termed them, ants are accustomed to touch all the objects which they desire to smell in every plane of space. The sense of smell in ants is, therefore, a contact-odor sense, or as Forel calls it, a relational "topo-chemical sense" which must enable its possessors to obtain very exact olfactory space impressions. Extero-ceptive orientation does not begin with the faculty of locomotion, but includes[4] orientation with regard to the organism's own body and its immediate neighborhood. In this case it can be either reflective or spontaneous.

(a) To the extero-ceptive orientation reflexes belong those reflective responsive motions which are provided with signs of locality, i.e., those which aim directly at the stimulative place. Among the spinal orientation reflexes of this category admirable examples known to every physiologist are the stroking reflexes of decapitated frogs when the legs are touched with acid and the scratching reflex of the spinal cord of the dog (Sherrington). Among the cortical reflexes are included here the plantar-reflex of the foot, and the reflexes of the eye and the ear (the focusing of the eye upon the optical stimulus and the turning of the head and of the eye towards the direction of the noise).

(b) The most advanced stage of oriented motions of the organs of the body comprises the spontaneous motion having a definite object, e.g., grasping, point-

[3] In the present article I make use, as in earlier works, in general of the clear and simple terminology employed by R. Semon to designate the processes of memory (Die Mneme, 2. Auf. Leipzig, 1908).

[4] According as the movement is towards the source of stimulus or away from it.

ing, and touching with the fingers, fixing with the eye, etc.

2. As soon as spontaneous locomotion appears orientation in space assumes other forms which are essentially different. It now comprises locomotor distance orientation which is no longer directed to the satisfaction of immediate needs from adjacent space, but is directed, in part, towards more remote biological purposes, including the quest for the opposite sex, the gathering of food and of building material for the nest, often from a very considerable distance, and finally, a change of nest and all sorts of expeditions for purposes of robbery or of war, together with the preliminary scouting expeditions. In short it comprises an entire biological world.

While a reflective orientation of the members of the organism is commonly liberated by any sufficiently powerful stimulus of the sense concerned (for example, a movement of the eye caused by some optical stimulus), it is characteristic of oriented locomotion that even in the most primitive cases it is only certain definite stimuli, specific both as to quantity and quality, to which the organism responds with an orientation which is usually likewise specific as regards preliminary signs[6] and direction. It is obvious that so highly specialized a process no longer has anything to do with the primary response to stimulus; it unconditionally involves rather the entrance of a new factor, that of memory. Acording to the nature of this memory process . . . two chief forms can be differentiated with respect to locomotor distance orientation: the more primitive one termed immediate or direct orientation and a more advanced stage called mediate or indirect orientation.

(a) We are concerned with direct orientation when the object of the locomotion is directly perceived by the senses as an actual stimulus. If a previously prepared mechanism present in the organism *ab ovo* corresponds to a specific distance stimulus, then the resulting orientation must be regarded as the *ecphoria* of an inherited engram-complex and this may involve either a tropism or an automatic reflex, or finally, an automatic instinct.

When a direct orientation follows without alteration in the incidental axis of the stimulus, we are justified in speaking of a tropism (Loeb, Verworn). In my opinion, however, this term should be exclusively confined to the corresponding simple responses to stimuli of the lowest organisms in which neither specific sense organs nor a central nervous system have been developed[7]. In the higher animals in which such apparatus are present, the "tropic stimulus" usually involves a complicated previously prepared automatism, namely, a reflective or instinctive automatism.

A reflective distance orientation can only be supposed when locomotion with a definite purpose is strictly connected with the continuance of an adequate direction-giving stimulus and when it ceases with the disappearance of the said stimulus. A frog, for example, creeps and jumps in pursuit of a fly only so long as the latter is in motion; as soon as the insect lights the amphibian loses all interest in the bit of food but now so eagerly desired. We may designate such reflective distance orientation as one-phase movement complexes, since in such instances the hereditary engram complex is entirely exhausted in the one phase of the oriented locomotion.

The case is otherwise with instinct automatism. Here there becomes evident the primary direction stimulus and already highly differentiated many-phased hereditary engram-complex which . . . can develop in all its phases in a somewhat autonomic manner, i. e., independently of the duration of the primary inciting stimulus. This is connected with two peculiarities of such many-phased hereditary complexes, or in other words, instincts. In the first place they are composed of a series of successive associated separate engram-complexes (temporary phases) which may be made manifest by so-called "phasogenic ecphoria" . . .[8] Secondly, most instincts also possess a certain plasticity or individual adaptability . . .

This may be made clear by an example. There are certain night moths which possess the ability to scent the female at the distance of a kilometer.[9] As soon as such a moth perceives this specific odor he will move in the direction in which the stimulus increases. Let us suppose now that a gust of wind blows away this extremely delicate emanation for a few minutes. Will the male interrupt his flight? Not so. Since the hereditary engram-succession (in the present case the different phases of the sexual instinct) has not yet been completed, but is rather in the first or orientation phase, the corresponding excitation of memory continues. Since, however, on the other hand, the tropic original stimulus which occasioned the progress has disappeared, the flight of the male is naturally no longer oriented, but assumes a restless, wavering character—in other words the little creature is "seeking" the lost stimulus.[10]

There is, however, a second possibility: the insect may have perceived the image of the moon in the foremost division of its many faceted eyes during its flight, which is practically in a direct line, and may have associated secondarily with the direction of its flight, this constant image of a stimulus-complex pertaining to another sense. This second engram-complex of direction might operate vicariously in place of the first and thus maintain the original orientation at least for awhile. . . .

As we have seen in those forms of direct orientation thus far described the inherited memory is quite sufficient at least for the mere production of the initial phenomena. Obviously, however, there is a direct orientation which is based upon the ecphoria of individually acquired plastic engrams. The stimulus complexes which occasion this ecphoria do not find in the organism a primary mechanism especially prepared for them, but owe their secondary-tropic power merely to the circumstances that their first effect was followed by a direct sensory attraction or repulsion. Consequently in every subsequent return of a similar (or even apparently similar) situation, the said reaction promptly recurs, because of a "similarity association," or a mere "analogy result." An example of this may be taken from Forel.

Forel[11] proffered to bees honey placed in artificial flowers of various colors made of papier maché. After the bees had discovered the food supply by accident, they pounced greedily upon all the artificial flowers and returned to the natural blossoms only after the last drop of honey had been licked up. After the lapse of a short time he then placed two small pieces of red and white paper in the vicinity of the flower beds which the bees were visiting, but without placing honey upon the paper. In spite of this the bees all rushed eagerly at these new attractions, examined them minutely, and only left them when they convinced themselves that there was no honey upon them. Bees, who had never made the happy discovery of a treasure of honey on paper would have paid not the smallest attention to the brightest of bits of paper.

(b) The most advanced stage of the capacity of locomotor orientation is attained in mediate or indirect orientation. . . . In contrast to direct orientation the goal of the locomotion is no longer given by the senses as a direct tropical stimulus but merely appears as an engram in the "sensorium." The ecphoria of this goal occasions the locomotion, i.e., it forms the inner impulse for it and accompanies it as a memory sensation while it lasts, but, of course, it can give no information as to the actual situation in space of the objects sought or the direction to be taken for the reaching of the said object. The direction of the locomotion, i.e., the true orientation, is in this case determined mediately through secondary intermediate complexes which are connected by association with the stimulus complex of the starting point on the one hand, and of the goal on the other, and indeed . . . through continual successive association.[12] Each of these intermediate stimulus complexes left behind it a corresponding engram complex and the entire series of the latter from the starting point to the goal forms, consequently, a successively associated engram complex. The process of indirect orientation consists, therefore, in the fact that each of these intermediate complexes upon its actual recurrence first causes the ecphoria of the corresponding engram. The memory sensation occasioned by this inner process coincides more or less closely with the original (secondary) sensation concerned; there takes place . . . what we may call, following Semon, an "identifying memory homophony," or in ordinary language, "recognition."

In this manner the entire intermediate complex from the starting point to the goal is redeveloped successively, so that naturally this memory succession must take place in the original series through the mere repetition of the following of the "outward-bound path." (i.e., the reiteration) and in the opposite succession in the case of the return path (i.e., successive reversion).

The return trip from a rambling expedition is in principle, therefore, a successive reversion of the outward-bound path (Raynaud's "Law of the Reverse Path").[13]

The theoretic foundation of this mechanism, i.e., in relation to the return from the first journey, encounters certain difficulties . . . Thus, for example, when a melody is sung backwards it is never recognized, and in the same way an optical succession which is reversed produces a very bizarre impression, as may be seen when moving pictures are run backwards. In the same way the return from a somewhat extensive first journey must be at the very least a very uncertain if not an impossible affair, since even the optical complexes encountered in the outgoing trip cannot be properly "associated" when the series is reversed. In reality, however, such a first journey never extends to great distances. The young animals learn to know the neighborhood of their nests quite gradually by means of "orientation journeys" to increasingly extended distances, so that each successive journey takes as its starting point the point which was the goal in the preceding expedition.[14] The final point of the first journey is doubtless within sight of the nest . . . and the first return trip is not a successive, but a simultaneous reversion of the engram complex. Thus, the distance journey is made possible by numerous intermediate complexes. Consequently, the successively associated intermediate complexes of an extended indirectly actuated distance journey are nothing more in practice than the original final stages of the previous partial journeys. In this manner indirect orientation based upon successive associated complexes may be regarded as derived from the direct orientation concerned with the original stages of the journey.[15] And the return trip from such a distance journey comprising a series of stages is in reality less an immediate reversion of the total series of successive complexes than the reiteration of a second succession in the opposite direction, which is also made up of stages like the outgoing succession, and which has been created independently of the latter.

We have hitherto assumed that indirect distance orientation is always created by several or many different intermediate complexes. As a matter of fact, however, this applies only to a very limited number of cases for which I prefer to reserve the name of *genuine associated memory of locality*. By this phrase we understand only that highest stage of the capacity of indirect orientation which is based upon the presence of a succession of numerous differentiated locality engrams. The characteristic type of such a memory of locality is the orientation of a human being in the streets of a familiar city by means of the successively encountered optical engrams of the various building complexes on both sides of the way combined with the kinesthetic engram complexes of the various branchings off now to the left and now to the right, etc. It is clear (and this is the final peculiarity of this differentiated, indirect orientation) that the relative direction, i.e., relative either to the starting point or to the goal, will be determined by the general direction of the journey.

(*Continued on page 375*)

[6] It must be considered a misuse of the term when Szymanski (Arch. f.d. ges. Phys. 138, 1911) recently referred to the concept of "Mnemo-tropism" comprising under this term those cases in which a definite direction is taken under the influence of a memory sensation (e. g. among ants as a result of the remembrance of a previous angular deviation which they had been forced to make). Only actual, i. e., original stimuli are capable of operating under all conditions "tropically" in the true sense of the word.

[7] This involves at the same time a certain force in order to carry to an end under all conditions the succession once begun: The memory emotion continues during the entire process.

[8] This instinctive unrest is commonly observed when the progress of a hereditary engram succession is suddenly interrupted by the elimination of the actual stimulus realized in the phase concerned. I have termed this phenomenon, by reason of the lack of a more beautiful Greek word, the "stimulus quest." This is characteristic, therefore, for the presence of a memory sensation. This phenomenon, among others, has also been quite correctly observed by Bethe but has been erroneously designated by him as the "questing reflex."

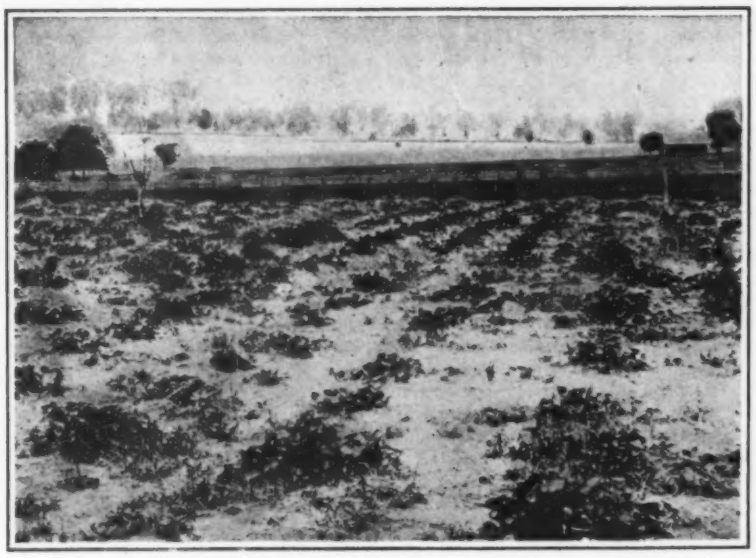
[9] A. Forel, Das Sinnesleben der Insekten. Reinhardt, Munich, 1910.

[10] The successive association of a series of engram complexes is occasioned according to Semon by reason of the fact that the successive single original sensations . . . continually overlap each other in such a manner that the beginning of each subsequent sensation is synchronous with the end of the previous one. Original sensations further separated from each other in time cannot therefore be associated to form a successive engram complex.

[11] Raynaud. Théorie de l'Distinct d'orientation, C. R. Acad. Sc. 125, 1897. L'Orientation chez les Oiseaux, Bull. Inst. gén. Psych. I, 1902. Bonnier (Rev. Sc. 1898) and Piérson (Bull. Inst. gén. Psych. 1904) referred the phenomenon to the "Muscular Sense," i. e., they supposed that animals execute on the return trip a minutely detailed reversion of all the kinetic figures evolved on the outgoing expedition.

[12] Several authorities have verified this mode and agree with each other in regard to it, including Hachet-Souplet (Carrier Pigeons) in Ann. de Psych. Zoöl. V, 1902, Buttel-Reepen (Bees) in Biol. Centbl. 1900), Bates, in "The Naturalist on the River Amazon," London, 1873, C. and E. Peckham (Other Flying Hymenoptera) in Wisconsin Nat. Hist., 1893, Ernst in Arch. f.d. ges. Psych. 1910 and 1914, and myself (concerning ants).

[13] Only by the aid of this assumption can it be explained how these apparently chance intermediate complexes, which in themselves have nothing to do with the goal, happen to serve in general as "guiding points."



A new growth of kudzu starting its first year

The same field as it appeared a year later

Kudzu, the Latest Forage Plant

A New Crop Developed from an Ornamental Vine, Which Appears to Have a Brilliant Future

By Robert H. Moulton

THERE are thousands of people in the cities throughout this country who grow climbing vines over summer house, front porches, pergolas, and so forth, for shade or screening. For many years honeysuckles, moon vines, cinnamon vines, virgin's bower, Virginia creeper, or some other plant has been grown. But there is another climbing vine that is becoming very popular, and that is the kudzu plant. This is a perennial plant, and one of the fastest growers known. It makes a beautiful growth, the leaves being a dark green, and produces a dense growth providing a splendid shade. But the kudzu plant has another virtue and one that should place it ahead of any other climber to-day. That virtue lies in its value as a food for stock. It is richer in protein than alfalfa, and animals thrive on it. Although a perennial, the vines should be cut down to the ground each fall at the approach of winter. The heavy growth of even one vine will sometimes make more than one wagon load of good hay.

This remarkable vine gives promise of being one of the leading sources of wealth in certain sections of the country in the near future, especially in some of the southern states. It really is a pea vine that springs up from the roots when the first warm days come in the spring of the year and grows vigorously until a killing frost comes in the fall. This gives a growing season in some states of at least eight months in the year during which several cuttings of hay can be made. Instances are known in which four cuttings of hay, averaging ten tons per acre, in a single season have been made. The hay is of the highest quality, being equal to cow peas or alfalfa and much richer than timothy.

The average analysis made by the State Chemist of Florida, where the vine is now quite common, shows protein 17.43 per cent and starch and sugar 30.20 per cent, which makes it a somewhat richer food than wheat bran. Another remarkable feature is that, although the hay is as rich a food as alfalfa, it is entirely free from the tendency to cause loose bowels and bloat in horses and other livestock which interferes so seriously with the use of alfalfa. When moistened, kudzu hay becomes almost like fresh foliage again and makes an excellent green ration for poultry in winter. It is well adapted for use in making mixed feed stuffs and for all other purposes for which alfalfa can be used.

The hay cures very quickly, retaining its leaves and bright green color instead of shedding as cow peas and velvet beans do; in fair weather only one day is required before it is ready to put in the barn. For this reason it can be easily cured in the fields in stacks and under duck covers, thereby obviating the expense of building barns. Labor can also be saved by using sweep rakes instead of hauling the hay on wagons after it has been cut with a mowing machine and raked into furrows with a common horse rake. Kudzu hay is worth from $20 per ton up, making the product of an acre yield $200 or over.

According to a number of authorities, kudzu is of even greater value for grazing purposes than for hay, since it requires no cultivation after the first season and will thrive upon land that is too poor and rough for any other crop. It has been found to do well on all types of soil from pure sand to the stiffest clay, provided the land is sufficiently well drained to admit of growing corn or velvet beans; where the soil is too wet to grow these successfully it is also too wet for kudzu. Like any other crop, kudzu will make a stronger growth on rich land, but it does well on land that is too poor for other hay crops and, moreover, rapidly improves the soil by adding nitrogen through the ministration of the bacteria on its roots. In this respect it has the same power as cow peas, alfalfa and other leguminous crops.

This addition of nitrogen to the soil and the protection from washing rains and the baking heat of the sun afforded by the dense growth of vines, causes rapid improvement in the quality of the land where kudzu is grown. And, while even poor soil becomes

Kudzu is a shade vine

rich within a few years when planted to kudzu, it is yet advisable to use some fertilizer the first season in order to hasten the growth of the vine until it can draw in atmospheric nitrogen. After this it will not require fertilizing, for its deep root system draws potash and phosphoric acid from the sub-soil, while its leaves draw all the nitrogen needed by the plant from the air. For this reason the soil becomes richer every year instead of becoming exhausted as in the case where grasses are grown for hay. The deep roots live to a great old age and become stronger and more vigorous as the years pass by.

One planting of kudzu is permanent and the yield of hay increases as the ground becomes more thickly set with the vines, taking root at the joints. The greater number of vines struggling for air and light creates a tendency to make them more slender and leafy, and this improves the quality of the hay by eliminating any coarse vines, thereby enabling horses and other livestock to eat it up clean without any waste. The vines that run along the surface throw out roots at the joints, and these, becoming new plants bind the soil firmly together, thus preventing the washing and erosion of hillsides by heavy rains. While this improvement is taking place the field is giving fine returns to its owner through the immense supply of rich forage on which the cattle, horses and other livestock can graze. The result is that they are kept fat and in fine health at a very small cost for eight months of the year.

The roots of kudzu penetrate so deeply as to make it proof against any dry weather that is ever likely to prevail in most sections of the country. This feature and its peculiar habits of neither blooming nor bearing seed under field culture, causes the vines to remain green and growing during the entire period from spring to fall. The hay can therefore be cut at any time that is convenient, when weather conditions are suitable for curing the hay, as kudzu is not injured by waiting for good weather as other hay crops do. This feature gives it an immense advantage over any other crop.

Kudzu is propagated by means of the plants that have rooted from the joints of the vines and when transplanted carry with them on their roots the tubercles that are needed to inoculate the soil of the new field. In planting kudzu the land should first be deeply planted, then harrowed, and finally checked into rows 8½ feet apart each way, setting a plant at each check. Tap roots should be laid along the bottom of the furrow, with crowns slanting upward to within two inches of the surface and then covered with loose earth to the level of the surface. This requires 1,018 plants per acre. One man and a boy can set several acres a day. The man carries a shovel and opens up the holes by sticking it in the ground and pressing the handle forward, while the boy, carrying the plants, sticks them in back of the shovel. The shovel is removed and the man steps on each side of the plant to press the earth firmly, after it falls back on the plant.

The proper time for planting kudzu is two or three weeks in advance of corn planting or a little earlier if one can get the ground ready. A full crop of corn may be grown on the same land, the first year, by dropping the grains between the plants. Neither will interfere with the other and both need about the same attention, only the ground should be left smooth and level at the last cultivation to permit easy rooting of the vines or runners and subsequent mowing for hay. Plants cannot root so well on a rough surface.

After the first year the kudzu will not need any cultivation, as the vines will run all over the ground the second season and take root at the joints, growing so rapidly as to choke out all other plants, even such pests as nut, Johnson and Bermuda grasses. At the same time it is an easy matter to get rid of kudzu if desired, for the plants will sprout only from the

The kudzu field of page 364 after a cutting of 4 tons per acre, to be followed by a second cut almost as heavy.

Kudzu and corn planted in rows five feet apart, showing appearance of the stand in July of the first year.

crowns and can be killed by cutting off the crowns with a disk plow in hot, dry weather. For this reason there is no danger that kudzu will ever become a pest.

Kudzu is perfectly hardy all over the United States and endures the winters as far north as Nova Scotia. It will, therefore, be a valuable crop in the northern states as well as in the South, although the longer growing season in the South is naturally an advantage.

One of the most successful growers of kudzu in this country is Mr. C. E. Pleas, Chipley, Florida, who was one of the first to discover the wonderful qualities of this plant as a forage. Mr. Pleas' discovery came about as a result of planting the vine for ornamental purposes, to cover a summer house on the lawn of his home, as all other vines had failed to cover it near the ground. After two summers' trial he grubbed it out, because the prostrate vines trailed all over the yard and grew so fast that he could not keep it confined to the summer house and in mowing the lawn the leaves made such a litter that it was given up as a bad job.

The three roots that were grubbed up were thrown on a trash pile where Mr. Pleas disposed of the trimmings from the roses and other shrubbery on the place, the idea being that, since it wanted to run on the ground, it would hide the trash pile from view. In three years' time the vines had covered all that corner of the yard, about 35 by 40 feet, to a depth of three to four feet, had covered all the fences and had reached the barn lot where the family horses were kept, and in such amounts that Mr. Pleas became alarmed, thinking it might be poisonous.

Accordingly, he sent some of it to the Department of Agriculture at Washington for examination. On being informed that it possessed no poisonous qualities, he began investigating and experimenting and found by repeated analyses its high percentage of protein. Since then he has grown it regularly every season and says that in his thirty-five years' experience in farming in different states, and with various hay crops, he has never seen a hay that cures so quickly, holds its leaves so well, or keeps its color so perfectly, under various conditions, as kudzu does.

Last season Mr. Pleas made the best corn ever grown in Florida, 40 bushels to the acre, after kudzu and without a particle of fertilizer. Furthermore, this was on land that had never before produced a good crop of any kind, being worn out soil. The kudzu completely rejuvenated it in two seasons.

Checking the Alignment of Diesel Engine Shafts*

By Geo. E. Windeler

EXPERIENCE shows that regular periodic overhauls obtain more efficient service out of engines with a lower average cost of upkeep. Engines overhauled only when they are on the point of breakdown are more costly in upkeep, and the user should realize that it is to his interest to keep his engine in first-class condition. Seeing that Diesel engine plants have had to run many hours owing to the extensive demand for electric power for war purposes, it may be assumed that many are in a state requiring considerable overhaul, and the present period is opportune for this work to be carried out.

One of the most important items is the question of alignment of the crankshaft, and I propose to refer to a simple and reliable method of detecting "out of alignment." The alignment of an engine is a most important factor. If the parts are aligned in a satisfactory manner there will be greater smoothness of working, less wear and tear and less tendency to break down at critical periods. It is not essential that an engine bedplate should be absolutely dead level, as would be indicated by a spirit level, but that when an engine bedplate is laid down its shaft should be lying in its bearings parallel with the top machined surface of the bedplate, and the shaft journals should be lying evenly and concentrically in the whole of the bearings in which they will work. From the top of the bedplate the whole of the superstructure and other portions of the engine will be erected. In the case of a vertical engine, these parts should stand correctly at right angles to the top of the bedplate, and therefore to the axis of the shaft. The crankshaft, formed with large intermittent gaps, produces a comparatively weak structure, which is liable to spring under ordinary handling; therefore great care must be exercised when bedding in a shaft to be sure that it is not strained in any way. Before proceeding to bed in a crankshaft precautions should be taken to observe that the bearing shells are bedded accurately, and without spring or slackness into the bedplate housings. The shaft should then be tried in its bearings and tested for concentricity and roundness of its journals. Neglect of this point is certain to produce unsatisfactory results. If the journals of the shaft are not concentric with each other or are out of round they should be filed and lapped or re-machined. The former course is the one usually adopted. When these parts are fitted the shaft should then be bedded in its bearings, the bearings closed down to their normal running clearance and the caps screwed hard home. This may be accepted as the usual procedure for bedding in a crankshaft.

But the question arises how to determine when it is necessary that this work shall be carried out. We will assume that an engine has been at work for some time, and that the engine user is contemplating an overhaul or refit. The chief consideration is time, and naturally he wishes to determine beforehand the amount of work that has to be carried out. The most important points to consider with the crankshaft are: (*a*) Is it being properly supported in its bearings? (*b*) Are the bearings in a satisfactory condition? (*c*) Are all the bearings, including the outboard bearing or bearings, in alignment with each other?

These important and difficult questions have not hitherto been easy to answer and decide.

The first indication that a shaft is being imperfectly supported in its bearings is excessive end play on the shaft with the flywheel running out of true. In most Diesel engine crankshafts the end movement of the shaft is limited by certain thrust collars, and it has been noticed that the end movement has often been seriously in excess of the actual mechanical clearance allowed. This excess led me to form the opinion that the excessive end movement was produced by the springing of the crankshaft for want of support, and that actually the shaft was being extended and contracted in length by the opening and closing of the gap between the crank webs. The difficulty was how to measure this distortion with the engine parts all erected, to decide the amount of want of support, and where the measurement should take place. The next step was to investigate whether the amount could be measured with the engine at rest and the whole of the reciprocating parts in position. It was decided to measure the distance between the crank webs when the crank pin was on the top centre and when the crank pin was on the bottom centre. It was found that a few thousandths difference in the dimensions between the crank webs when the crank pin was on the top and bottom centre indicated that the shaft was out of line. This method was especially valuable in checking the alignment of outboard bearings. It was proved that, if a shaft was not being supported at a particular point, by placing the crank pin of that particular line of parts adjacent to the unsupported bearings at (*a*) the top centre and measuring between the crank webs at a predetermined point, and then (*b*) placing the crank pin on the bottom centre and measuring as before, a distinct difference was noticed. If the bearing was low the crank webs would close in when the pin was on the bottom centre, and open out when the pin was on the top centre. If an outerboard was low the reverse was the case, the weight of flywheel causing the crank webs to open when the crank pin was on the bottom centre and close in when crank pin was on top centre. It can thus readily be determined which bearing or bearings are low, and the higher bearings can then be scraped down to suit. This simple method can be applied by any one, and does not require any special skill or training.

The instrument first used for these tests was an inside micrometer, having telescopic rods so that variable lengths could be dealt with. This instrument required very skillful handling, and a device was produced which could be used by any one, and would register correctly the amount of difference in the dimensions taken between the respective crank webs.

*Abstract by the *Electrician* (London) of a Paper read before the Diesel Engine Users' Association.

A Method of Determining Wind Velocity and Direction in the Upper Air by Sound

THE usual method of determining wind velocity and direction in the upper air is by observations, with theodolites, of small rubber balloons filled with hydrogen, and rising at a known rate. This method fails on the numerous occasions when low cloud or fog interferes with good visibility of the balloon. The method described by Bourgeois consists in the registration by suitable apparatus of the direction of the sounds produced by a series of explosions of "crackers" carried by a balloon filled with hydrogen. The method thus substitutes sound registration for direct optical observation of the position of the balloon. The balloons used are just over 1 m. in diam., and the total weight of the "crackers" required for one ascent is about 200 gm. Yet the explosions can be heard and recorded up to distances of 15 km., in spite of winds of velocity greater than 10 m. per sec.—*Science Abstracts.*

The Texture of Sands*

Interrelation of Chemical and Mechanical Constituents

ALTHOUGH chemical analyses of sands have frequently been made for industrial purposes, and mineral analyses are now a feature of geological investigations into the petrology of sediments, comparatively little attention has been paid to the mechanical composition. This is particularly the case in the matter of the interrelation of the mechanical composition with either the chemical or mineral constitution.

The connection between the mineral and chemical compositions of sediments is clear, the minerals representing the particular manner of grouping of the chemical elements. The relation of the mechanical composition to either the chemical or mineral constitution opens up a big field for future work, equally of considerable geological interest and immediate industrial application.

Sediments can be graded, according as they are coarse or fine, by screening or by elutriation in currents of air or water. The latter method has almost entirely replaced the older and less scientific one of subsidence. If screening is to retain any pretensions to accuracy, it cannot be carried out with sieves of less than 0.25 mm. aperture. On the other hand, elutriation of material more than 0.4 mm. in diameter is difficult to control on account of the eddies set up by the high velocities of the water-currents (47 mm. or more per second). In the mechanical analyses of sediments the two methods of procedure may be successfully combined, material more than 0.25 mm. in diameter being sifted, and that 0.25 mm. in diameter or less being separated into grades by elutriation in water. (While elutriation by air-currents has been adopted commercially for grading the products of fine grinding, such as cement, silica-flour, barytes, etc., it cannot be considered sufficiently accurate for scientific work.)

It is regrettable that no general agreement exists as to the grades into which sediments should be separated. Soil analysts have adopted a series which, for certain cogent reasons, has not commended itself to those geologists who have worked at the problem. Another and different set of grades has been adopted by the potters in the separation of clays. The fact that comparatively few tables of mechanical analyses have yet been published is the strongest possible argument for agreement without delay upon a definite set of grades.

Such a division of sediments into grades is necessarily artificial. Nevertheless, the grades adopted by the geologists have as their basis the natural characteristics of the material so-named as observed "in the field." The grading system frequently adopted is:—>2 mm. diameter, gravel (G); >1 mm. and <2 mm., very coarse sand (VCS); >0.5 mm. and <1 mm., coarse sand (CS); >0.25 mm. and <0.5 mm., medium sand (MS); >0.1 mm. and <0.25 mm., fine sand (FS); >0.05 mm. and <0.1 mm., coarse silt or superfine sand (cs); >0.01 mm. and <0.05 mm., fine silt (fs); and <0.01 mm. diameter, clay or mud (c). It is a matter of controversy as to how far material of diameter less than 0.01 mm. may be accurately separated. Both elutriation and subsidence methods of separation can be arranged, but the testing of the accuracy of the process by actual measurement presents difficulties. A separation has, however, frequently been effected by subsidence methods supposedly accurate at the point 0.005 mm. diameter.

The grade sizes chosen are not of such great moment if graphical representation of the sediments by means of curves is adopted. For example, in Figure 1, the method of plotting cumulative percentage weights against grade size is utilized. To keep the diagram within reasonable compass, the grade sizes are plotted horizontally at distances proportional to their logarithms. The ordinates at the grade size represent for each curve the percentage weight of material greater than that grade size. It is obvious that if a particular sediment be subjected to mechanical analysis upon a basis of grade sizes different from the above, the results should yield the same curve.

In the strict geological sense, the expression "sand" is a grade term, and is limited to material ranging from not less than 0.05 mm. to not more than 2 mm. in diameter. A perfectly graded sand would be one consisting of grains each with the same mean diameter. Such a sand has never been found naturally, but the ideal is closely approached by certain dune-sands which have been exposed to the transporting action of winds and water so frequently that grains smaller or greater than the average have been respectively carried ahead or left behind.

The term "sand" in the commercial sense, however, is used for sedimentary material of varying grades (as, for example, moulding sands), or even for the unclassified products resulting from the crushing of hard siliceous rocks, etc.

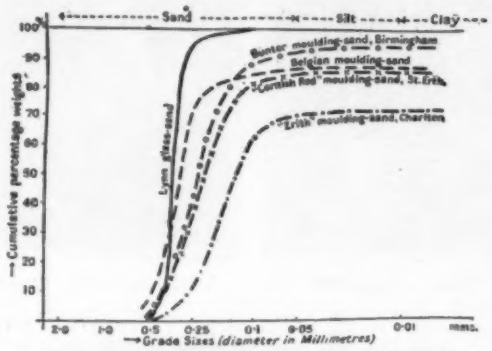


Fig. 1—Graphic presentation of the mechanical composition of five sands

The texture of sands used in the casting of metals and alloys (particularly, perhaps, of steel, where the conditions are the most exacting) is of considerable industrial importance, as well as of scientific interest. When samples of the sands which have proved most successful for steel moulding are subjected to mechanical analysis, it is found that each consists of a high

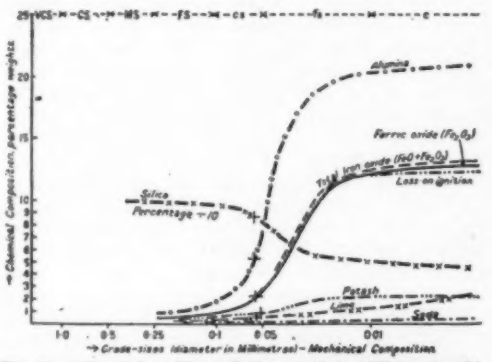


Fig. 2—"Cornish red" sand for steel moulding: graphical representation of variation of chemical composition with grade. The large crosses + indicate the chemical composition of a "bulk" sample before elutriation

percentage by weight of the sand grade, a relatively large proportion of the clay grade, but little or no silt or superfine sand grade. Graphically expressed, the mechanical composition of such sands, of which "Belgian yellow" and "Cornish red" are apposite examples, is shown in Fig. 1. The sand grade consists preferably of coarse or medium sand, the Belgian material being

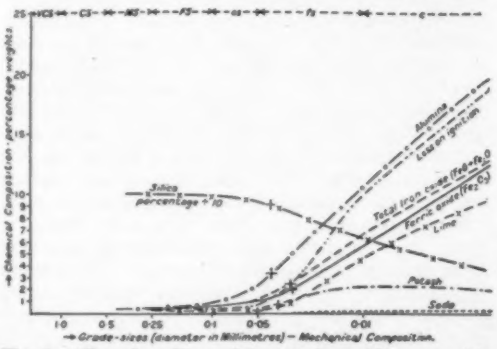


Fig. 3—"French red" sand for steel moulding: graphical representation of variation of chemical composition with grade. The large crosses + indicate the chemical composition of a "bulk" sample before elutriation

therein more suitable than that from Cornwall (St. Erth). Verticality of the graph over the region of the sand grade marks the preponderance of this grade, and horizontality over the region of the fine sand and silt grades indicates the relatively subsidiary character of the latter. This peculiarity in grading of moulding sands may be interpreted in the light of their behavior in the foundry. A maximum pore-space would be yielded by a rounded sand uniform in grade. The presence of coarse, rounded grains in the sand mentioned above, therefore, permits the escape of the gases and vapors produced when the hot metal enters the mould. In short, the mould is said to be well "vented." If silt and fine sand were present in any considerable quantity, this natural venting would be gravely impaired. The clay grade is required to act as the "bond" uniting the sand grades together. Both the Cornish and Belgian sands mentioned have a strong bond—that is, contain a relatively high proportion of true clayey material (14 to 20 per cent.). The ideal condition in which the clayey bond exercises a maximum effect is that of a pellicle, as thin as possible, completely enveloping each quartz grain.

In contradistinction to such peculiarly graded sands (for they are abnormal geologically, and hence are of restricted occurrence) are the well-graded materials desirable for glass manufacture. A sand such as that from near King's Lynn (Fig. 1), which contains a high percentage of grains belonging to the medium sand grade and practically no silt or clay, passes freely and evenly into melt, thereby assisting to produce a homogeneous glass as rapidly as possible.

The inter-relation of chemical and mechanical constitution is well brought out in moulding sands of good quality like those from St. Erth, Cornwall, and Fontenay aux Roses, near Paris (Figs. 2 and 3). Not only must the sand be composed of suitable grades; it must also be highly refractory to heat, and capable, for example, of withstanding the effects of molten steel run from converters and electric furnaces. ("Open-hearth" steel is not so exacting upon the sand.) The refractoriness to heat is indicated by the fact that chemical analysis of the coarse, medium, or fine sand grades shows them to be high silica sands containing only small proportions of alkilis and alkaline earths.

The variation of chemical composition with grade is expressed graphically in Figs. 2 and 3, where the high silica content of the sand grades is evident. Analysis of the clay grade shows that its composition closely resembles that of many first-class British fireclays, which are also very refractory. In addition, the diagram illustrates the presence of a relatively high percentage of hydrated ferric oxide; this compound is probably present in a colloidal form, and is responsible for much of the wonderful strength of the bond of the moulding sand.

The widespread American practice, now of many years' standing, of milling together a naturally occurring siliceous sand with a good fireclay and a certain amount of an artificial bond, such as dextrin, flour, molasses, etc., is in this connection very significant. It yields an indication of the manner in which the absence of the remarkable naturally bonded sands of Western Europe has been compensated by the production of an artificial mixture of somewhat similar chemical and mechanical constitution, the resemblance having unwittingly been evolved.

Similarly, the study of the variation with grade in the mineral constitution of a sand presents results of great interest. The detrital minerals occurring in each grade vary in proportion, species, and physical characters. Generally speaking, the percentage weight of the heavy detrital minerals in any grade varies inversely with the grade size.

From *Nature* (London).

The Dynamical Theory of Electric Engines

L. B. ATKINSON, in the Tenth Kelvin Lecture, first discusses the theory of the action of electric engines converting electric energy into mechanical work i. e. electric motors. Formulæ are found for the efficiency of the ideal engine in every case and the superior limit to this efficiency is pointed out. Cycle diagrams are constructed which show the analogy with the theory of the perfect heat-engine. All the possible primary types of electric engine are enumerated. Electric generators, that is, the engines which convert mechanical work into electrical energy, are next discussed. The theory of the electrostatic generator is explained and the possible future developments are indicated. Finally, combined generator and motor cycles are considered by the principle of the conservation of energy, first clearly enunciated by Kelvin. The author lays stress on the importance of these considerations to the designer.

The mathematical formulæ are worked out more fully in the Appendices.—*Sci. Abstr.*

Airplane Wing Design*

Various Theories of Fluid Motions Around a Wing Plane

By Walter C. Durfee

THERE are several subjects which seem so interesting in connection with a study of the action of wings upon the air that the writer has thought it valuable to the Society to place them on record, in brief outline and in such a way as to provide a starting point for discussion and the addition of any data which members of the Society may wish to contribute. These subjects which have reference to the theory of fluid motions around the wings of airplanes are as follows:

(*a*) The vortex theory of lift, which states that the air which passes the wing of an airplane, or the blade of a propeller, contains a component of circulation around that wing or blade, in such a direction that there is comparatively high velocity and low pressure on the upper surface of a wing; and a comparatively low velocity and high pressure on the under surface.

(*b*) A theory which states that an imperfect fluid will act like a perfect one momentarily; from which it may be inferred that the circulation around a wing cannot exist at the first moment or beginning of its motion of advance but must develop at some time after the first beginning of the motion, since there is no circulation in the beginning.

(*c*) The vortex theory of shape, which treats of a solid body in motion as being somewhat similar to the core or kernel of a group of vortices.

(*d*) The hydrodynamic-electromagnetic analogy, which states that distributions of fluid motion are very similar to distributions of magnetic flux; so that one may calculate the fluid motion around a supposed vortex or group of vortices mechanically, by arranging electric currents or groups of currents in a manner analogous to the supposed vortices, and measuring the magnetic forces which result.

(*e*) The laws of vortex motion with reference to the action of vortices on each other, by which it seems possible to estimate the circulation or strength of the trailing vortex loop which is generated by a wing in flight.

(*f*) The laws of the actions of vortices with reference to their images in solid surfaces combined with the laws, so far as known, concerning the generation of eddies and vortices by friction, especially near sharp edges.

(*g*) The concept of a local direction of the wind as due to the effect of all vortices existing in the neighborhood of a wing—such as its own trailing vortices and the influence of neighboring circulations.

(*h*) Laws concerning the energy contained in various distributions of vortex motion by which one may estimate favorable arrangements of the trailing vortex systems in terms of the load carried by various parts of the wing span, and from which the drag might be estimated.

(*i*) Coefficients of friction and head resistance representing losses of energy which can be added to the losses attributed to the energy of the trailing vortices.

(*j*) Experience concerning the explosion of eddies and vortices and the causes and effects of such disturbances.

It is the writer's belief that there are engineers, mathematicians and experimenters in the Society who can give illuminating and interesting statements concerning the subjects mentioned; and that a group of such statements assembled in the form of a discussion would constitute almost a complete and classical theory of the action of wings in steady flight. This paper, therefore, outlines in a preliminary way the bearing of these various theories and indicates their approximate exactitude.

(*a*) THE VORTEX THEORY OF LIFT

It is not difficult to believe that a component of circulation exists around a wing in flight. If it is granted that the wing carries any load at all, as wings evidently do, there is certainly a difference of air pressure between the lower and the upper surface. Consequently there are accelerations in the neighboring fluid form the under surface around in various circuits to the top surface; corresponding to the fall in pressure from one surface to the other. The quiet or still air into which a wing advances, experiencing these accelerations, must accumulate an upward velocity in front of the wing, and disturbances of a similar nature evidently must occur not only in front of the wing but also to the right hand and to the left hand. Since an upward motion in one region involves a downward motion in another, there must be a downward motion somewhere. Actually there is a sort of circulation up in front and down behind; and consequently to the rear above and in a forward direction below.

Fig. 1—Illustrating the theory of initial motion around wings

In practice such motions can sometimes be seen in the form of little jerks or jumps of a fluid in the neighborhood of a model wing passing through it. It is not difficult to believe that this disturbance around a wing is rather similar in arrangement to the distribution of velocity around a vortex or group of vortices—their axes parallel to the span of the wing, and perpendicular to the direction of advance. The intensity of motion is very likely greatest near the seat of the disturbance.

According to mathematical theory the lifting force would be in proportion to the strength of the vortex and to its rate of advance, just as the lifting force on a wire in the armature of an electric motor is in proportion to the strength of the current and to the intensity of the magnetic flux from the pole pieces. A formula is given in the Encyclopedia Britannica for the theoretical action of a vortex which surrounds a circular rod which is projected sideways. A force developes perpendicular to the axis of the rod and vortex and at right angles to the motion of advance. This is very similar to the lift of a wing in flight.

Practical examples, however, suitable for mathematical analysis seem to be very rare, nevertheless the writer found one case which seemed to be reasonably free from objectionable complications. This was a wing tested by Eiffel (Eiffel No. 8, at 9 deg. center section). From the measured pressures in this case the probable approximate velocities of the air near the wing surface were estimated, using Bernoulli's theorem. From these velocities a calculation was made of the circulation around the wing, which is the line integral of the tangential component of the velocity vector in a circuit around the wing. The result agrees with the theoretical formula for lift, or $L = \rho\, V m l$, in which L = force perpendicular to advance; ρ = density of air; V = velocity of advance; m = circulation of the vortex; and l = length taken along vortex axis. It would be interesting to have more measurements of the circulation around wings.

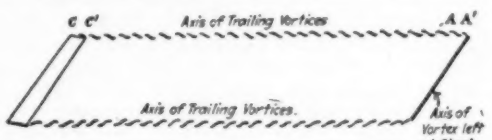


Fig. 2.—Further illustration of theory of initial motion around wings

(*b*) THEORY OF INITIAL MOTION AROUND WINGS

It is very evident that no circulation exists around a wing when it is standing still in quiet air on the ground. Mathematical theory further declares that circulation cannot be expected to develop immediately at the beginning of the advance. In the first instant of motion conditions are supposed to be very much as they would be in a perfect fluid. The amount of circulation if zero at the start would be zero immediately afterward. For example, imagine, for simplicity's sake, an inclined plane moving from the position AA' to BB' in Fig. 1, starting suddenly from rest. The volume equivalent to the space AA'—BB' can be expected to be displaced and to go around the edges in such a manner that there is no net circulation around the section. Very soon after this beginning of motion however, in the case of a real wing suddenly started in a real fluid, a very violent eddy or vortex is left behind at $A'B'$. When the wing has advanced to a further position CC' the conditions are as sketched in perspective in Fig. 2. There is a vortex loop stretching rearward from near the wing tips and joined together by the eddy generated at the starting point.

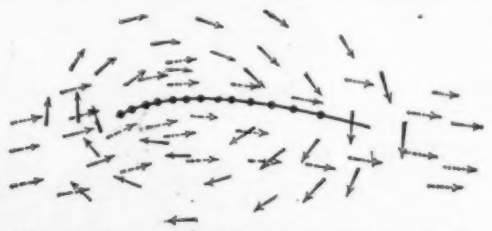


Fig. 3—Illustrating hydrodynamic-electromagnetic theory

(*c*) VORTEX THEORY OF SHAPE

Suppose that the axes of a number of equal-sized vortices are arranged as the circles in Fig. 3. Then the direction of motion in the fluid due to their combined action is almost exactly[1] in the directions indicated by the full-line arrows. Suppose that a certain motion of translations is added to this particular arrangement of vortex motion. Then the resultant velocity of total result may be in the directions indicated by the dotted arrows. This particular kind of fluid motion corresponds to a certain velocity of motion added to a certain arrangement of vortices.

Now it is a fact that the shape of the curved line of circles shown in the diagram is, as nearly as may be judged, the effective shape of a cross-section of a certain real wing (Eiffel No. 8 at 9 deg.), deducting an allowance for the thickness of the section. Also it is a fact that the spacing of the circles indicates the actual distribution of lifting force experienced by that wing between the front and rear of the wing section. Also the component of horizontal velocity added to produce the dotted arrows is the velocity used in the published tests of this real wing, and the vortex strength used in preparing the diagram agrees with the vortex theory of lift and the estimated circulation around the wing mentioned. Altogether, it is evident from these figures that there is a close connection between the factors of lift, distribution of lift, strength of circulation and distribution of fluid motion and shape.

(*d*) HYDRODYNAMCIC-ELECTROMAGNETIC ANALOGY

Diagrams like Fig. 3 are easily obtained, not by mathematical calculation, but by arrangements of electric currents and magnetic fields representing vortices and velocities, choosing any desired amount of flux to represent a standard velocity.

(*e*) ACTION OF VORTICES WITH REFERENCE TO EACH OTHER

The Encyclopedia Britannica gives formulæ for the action of groups of parallel columnar vortices upon each other, in terms of the strength of these vortices and their distance apart. It is interesting to estimate the strength of the trailing vortices from a biplane by observing their actions on each other. The pairs from the right-hand wing tips are of one kind or direction and revolve around each other in approximate circles. Those from the left-hand tips also revolve around each other, but in the reverse direction from the first-mentioned pair. Very careful experiment would be required to detect any error in the vortex theory of flight in terms of the action of these pairs of trailing vortices.

(*f*) ACTION ON VORTICES WITH REFERENCE TO THEIR IMAGES

Many peculiarities of fluid motion are roughly explainable in terms of the action of eddies as if under the influence of their images in solid surfaces. For example, there is a remarkable difference in the circumstances surrounding the eddies formed at B and B' in Fig. 1 on the upper surface of the plane. The one at the rear B' should tend to pass off if considered as under the influence of its image. Conversely, the one at A should tend to remain with the plane.

(*g*) INFLUENCE OF THE LOCAL WIND

Vortices, although regarded as having their axes in some particular location, are usually considered as having an influence through the fluid in which they exist, just as the magnetic effect of a direct current is considered as having an effect at remote distances. It is interesting to calculate the effect of this influence on a wing of short span. Such a wing in horizontal flight does not act as if encountering a horizontal on-

(*Continued on page 371*)

*Paper presented at the Spring meeting of The American Society of Mechanical Engineers.

[1] "Almost exactly," because the diagram contains an almost imperceptible allowance for the termination of the sustaining vortices within the length of the wing span and for the influence of their rearward extensions as trailing vortices.

Copyright, Japan Press Illustration Co.

Sorting and packing resistance units for transport or storage

Removing resistance-coil castings from the molds (compare frontispiece)

Iron and Steel Manufacture in Japan

The Japanese as Creators and as Imitators

By J. F. Springer

THE Japanese have shown a wonderful capacity for the assimilation of the developments of modern Western civilization. This fact is so precisely and unassailably true that in our recognition of it we may lose sight of the internal progress of Japan in respect to the industrial and the fine arts. The Japanese have a material civilization which they themselves developed; and, while they may perhaps recognize the general superiority of that which we may conveniently call Western, still there is an intrinsic value to much of the old. Moreover, the older work, in so far as examples of it have survived, constitutes an important source of the history of the people. They can not very well be understood apart from a knowledge of their capacity to originate and develop. If one considers simply the more salient features of Japanese history from the time of Commodore Perry—that is, from the middle of the Nineteenth Century—he is apt to get the idea that these people are wonderful as imitators of the West, but have little creative ability.

The Japanese have had artistic conception of a high order and a corresponding techinque adequate to execute the visions of the mind ever since the middle of the Sixth Century. Perhaps they had something of the kind at a still earlier period. For the period mentioned there are still extant examples of carvings in wood and metal that astonish students in respect to the thought involved and the workmanship displayed. The incentives to the development which may be traced back to the aforesaid middle of the Sixth Century are doubtless to be found in such large demands as those made by the erection of idol temples and the prosecution of wars local to the islands. The temples required decorations and idols; the wars called for armor. Naturally, these particular demands have by now sunk to zero or to a comparatively low point. Present incentives are more or less determined by the desire to secure and maintain a place with Western nations.

This may tend for some time to come to repress their own originality. There is so much to absorb that a large part of the native vitality must be occupied in effecting the absorption. It is perhaps nothing more than simple justice to recognize whatever examples of present-day originality come to light not as the sum total of the nation's ability, but as indications or examples of what could be done were the leading industrial minds freed from the necessity of accepting and adapting a great mass of Western achievement. For example, before we can very well expect the Japanese to do themselves full justice in the invention of power-driven metal-cutting tools, they must first develop metal manufacture in the modern sense throughout their land. When a million or so Japanese workmen and superintendents and designers have learned, adapted, installed and become versed in operating what the United States, England and France have accomplished in inventing and perfecting such tools, then there will be opportunity for the mechanical minds of Japan to conceive and work out new inventions on a scale comparable with leading Western nations.

Just now, Japan is too much occupied in catching up with the West to have much opportunity to do anything else. What does come from that country must be looked upon as representative of what she may be expected to do on a large scale when she is fully abreast industrially with Western peoples. The older achievements may be regarded as also representative of the native ability to conceive and execute. No doubt, a good deal of the older work was executed at a frightful outlay of time. But this remark would probably apply to much that the Western nations were doing in times not so very far distant in the past. Once awake as to the way in which time affects cost and cost affects extension of use, the Japanese may be expected to direct their creative ability into really practical lines. The thing to make sure of is that they do actually possess this creative ability.

In view of what has now been set forth, more than individual interest will perhaps attach itself to pre-modern examples of the progress made by the Japanese in the working of iron. Two of the illustrations refer to a wonderful raven. This is an example of ironwork executed probably in the neighborhood of 1700. This artistic work is an *okimono;* that is, an ornament to be set in the ceremonial niche belonging to a room in a Japanese house. It is about 18 inches in length. Because of this considerable size, the raven, it is supposed, was probably originally made with a view of installation in some great house or palace. Iron is not a material that lends itself very well to plastic work; and yet this raven is considered a very fine representation of the living bird. It is now one of the treasures of the New York Metropolitan Museum of Art; but, prior to its acquisition by this institution, it constituted the principal piece of a well-known Parisian collector's assemblage of examples of Japanese ironwork. Dr. Eduard Mème, the collector in question, acquired the work a considerable number of years ago. It has been on exhibition at the Museums Guimet and Cernuschi. There is a signature, in Chinese characters, underneath the tail. The name thus given is Myochin Shikibu Kino Munesuké. "This Myochin is evidently the Munesuké who flourished in Tokyo, or Yedo, in the early years of the Eighteenth Century. The exact period is 1646–1724. This artist or artisan was distinguished for his work in repoussé. "He it was who prepared helmets (hachi) embossed in fantastic forms for members of the Shogunate, together with plastrons and shoulder guards with splendid dragons in relief. Armor making, indeed, was his true claim to recognition as a member of a distinguished family, for he was the official representative

Copyright, Japan Press Illustration Co.

Scene in a Japanese foundry, melting the iron in small crucibles

of the twenty-second in descent from the first Myochin Munesuké, the great artist-armorer of the Twelfth Century. The second Munesuké, it appears, was a versatile genius; he is said to have wearied of preparing armor for a court which was always at peace, and he was constantly tempted by tasks which lay beyond his field. So he amused himself and startled his distinguished patrons by exhibiting objects which had never before been produced in iron. From huge eagles to minute fire-flies he forged ornaments of all sizes and forms. What his fellow-artists would model in wax, for bronze-founding, he modeled at once in armor-steel, and he is reproached with having forged princely armor with less skill than he made toys." I have been quoting from Mr. Bashford Dean.

Much of the work bearing the name Munesuké is thought to be probably forgery—"but the present object is apparently the exceptional one." It is an example of steel repoussé and is said to be equal to the best produced at its period. The raven is admired for its life-likeness of form and posture. The groovings by which the feather effect is produced are very successful in their results. The work is seen as a feathered raven. "When the collection Mène was exhibited at the Hotel Drouot it was interesting to stand near the case of the raven and study the effect he made upon his visitors. They would come up, one afer another, and glance at him in the hurried way of auction-hunters; then their expression of haste faded away and they would examine him quietly, sometimes circling about till they came to rest at the right point of view. His, in fact, was the only case in the gallery before which visitors would usually come to a full stop. And their remarks showed clearly that they appreciated the artist's point of view. In fact, in an instance of this kind, the Parisian art-collector is singularly apt to seize the conception of the Japanese."

Pretty much all of the foregoing statements as to this particular work and as to the activties of the great family of the Munesuké tend to show that the Japanese do possess creative ability and the power of execution. Munesuké the 2nd is an example of a man whose abilities refuse to be chained to his normal work. Souls like this, which reach out beyond the thing at hand, are of the stuff of which the great modern inventors are made. This instance of a Japanese living some six centuries ago is an indication that Japan possess inventor material. He is, perhaps, a better indication of this than the author of the raven. This latter Munesuké is an example of the man who sees what is presented to his senses so clearly and unmistakably that he is able to reproduce it in an unresponsive material like steel. Carried over into the field of invention, this analysis may not make of this Munesuké an inventor of the highest order. Still there is much very valuable invention which proceeds first by recognizing clearly what is wanted and then marshals the resources of the particular industrial art to produce the thing desired. A great deal of invention consists in perceiving a want and then working to supply it.

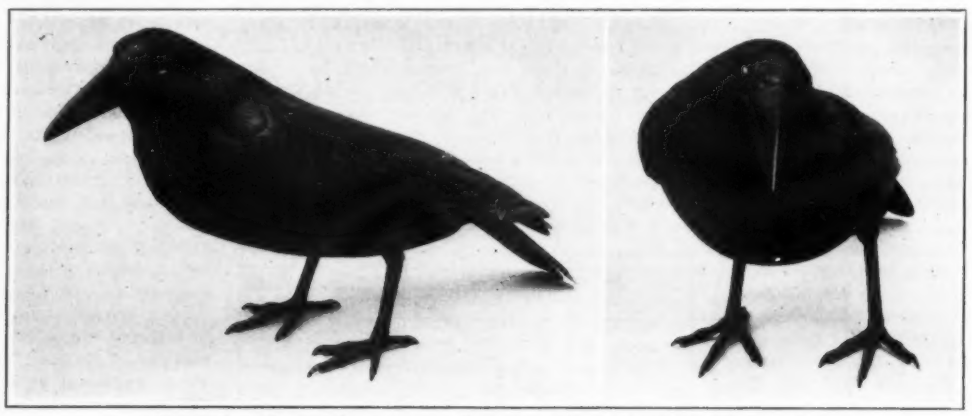
One of the illustrations shows an example of Japanese armor-making. This work is referred to about the same date as the raven. Naturally, in a piece of armor, the integrity and quality of the metal itself must be very high. Nothing less could very well be tolerated. The mechanical operations of forging it to the finished shape tend to test the quality. The suit of armor shown in the engraving belongs to the time of Japanese history known as the Tokugawa period (1603-1868), or more particularly to about the time of the reign of the shogun Tsunayoshi (1681-1708).

The use of iron in some form reaches back doubtless to prehistoric times. Japan and Corea are both supposed to have produced iron at a very early period. At any rate, the preceding concrete examples show that, in comparatively recent times, the Japanese have been skilled workers in the production and forging of the great metal. In addition to defensive articles, such as helmets, greaves, etc., these people became wonderfully skilled in producing the finest of tempers and the keenest of edges upon swords. This argues for a considerable mastery of the possibilities of iron.

The Japanese of the present day are becoming alive to the importance of iron in modern Western civilization. Sooner or later—if the thing is not already accomplished—they will see that those nations which possess coal and iron and understand the metallurgy of the metal and the advanced methods of manufacture are precisely the nations which stand at the forefront of civilization and are the wealthiest of all the peoples of the earth. Japanese traveling through middle and western Europe and the United States can hardly fail to see the part played by iron and steel—that the whole fabric of modern material welfare is dependent upon the great metal and the great alloy. Naturally, it will take time for all this to penetrate the mass of the people. The penetration has, however, already begun; so that a few years will doubtless show marvels. In 1917, Hi Sibley stated, there were twenty-one motor trucks in the entire Empire. Tokyo is a city of the size of Chicago, and yet its dependence, for local transportation needs, is upon the little Japanese horse and the Japanese coolie. It took four hours to get a "rush" package delivered from a store half a mile away from the destination. The one, solitary motor fire engine in the Japanese Empire was not possessed by Tokyo, but by Yokohama. The city authorities of Osaka, desiring to put their city on the map, thought of getting a similar engine; but when they learned the cost, their hearts failed them. All this constitutes, however, an extreme example. Other manufactured products based on iron are really coming into use.

Copyright, Japan Press Illustration Co.

Drafting room of Tokyo Street Car Engineering Dept.



Raven in embossed iron—an excellent example of Japanese metal work

Japanese armor of 1600 A. D.

One can get a glimpse of the way the methods and processes of the Western world enter Japan by considering with Hi Sibley the case of S. Ikegat. About 1890, this man was a small builder of marine engines. The demand increased so that he was every now and then compelled to extend his business. This would naturally involve the purchase of machine tools from England, America or elsewhere. The expense for the imported machines was such that eventually M. Ikegat concluded he would see what he could do in the way of building a metal turning lathe. The first machine was necessarily a rather crude affair; but improvements followed as more machines were built. Orders for lathes came from the outside and the business grew. In 1917, this man was the president of the Ikegai Iron Works, Ltd., with a capitalization of about $1,000,000. The yearly output of lathes and other devices was about $1,000,000. The company operates two distinct plants. The larger one turns out machine tools only; the other is engaged in producing marine engines.

The machine tool works, exclusive of the foundry, has a floor space of some 40,000 square feet. Light and heavy lathes, drill presses, boring machines, gear hobbers, milling machines, turning mills, planers, shapers, etc., are being manufactured. Naturally, this works became of importance during the Great War. One order from the Russian Government called for 800 lathes of American type—8 feet by 20 inches. The quality of machine tool turned out is below American standard; the workmanship is inferior, and the machine is not so efficient. "But quality is only comparative, and so we say the Ikegai works deserve great credit." The number of engine lathes in the works was 170; of planers, 15; of drilling machines, 32; of grinders, 36; and so on. Aside from machines built by themselves, the equipment seems to be mostly of American make. The Ikegai works is apparently more or less awake to the importance of using in its own plants equipment from nations that are veterans in the production of machine tools and the like; but this understanding of the necessities is not universal among the interests controlling other plants. It is said that stockholders, not being engineers themselves, have difficulty in understanding why foreign equipment should be purchased at double the price for which *apparently* the same articles can be bought right in Japan. But this point will eventually be comprehended, and then Japan will be on the road to supply herself with home-made machine tools.

What hinders progress now, and what will continue to hinder it for some time to come, are two things: (1) the dense ignorance of the average Japanese workman, and (2) the low cost of labor. That motor trucks and the like are not more in demand, for example, will be better understood, perhaps, when it is realized that the day wage of a Japanese coolie is 20 to 30 cents. So, goods for local transportation are largely loaded upon human backs and into man-drawn wagons and carts. Human legs transport the freight to its destination. The coolie is so available and so cheap that the Japanese horse scarcely holds his own in competition with him. Thus, in Tokyo, the generality of shops make delivery by human muscle. There are a few exceptions. The Mitsukoshi, the biggest and most modern department store in this city, with its area of sixty square miles, employs a lot of light wagons drawn by horses. However, the bicycle, the motorcycle and the motorcycle with side-car are in use to a certain extent. On the whole, however, the coolie reigns supreme. He carries some loads and draws others. In the latter case he may upon occasion be multiplied to a team. Boys of eight and ten draw big loads of light merchandise; their fathers, uncles and big brothers are draft animals for drawing uncut timber, heavy machinery, steam boilers, and the like. The street sprinkling of the great city of Tokyo is, except for the central part, done by one-man sprinkling carts. As to ignorance—"The great mass of coolies are so hopelessly ignorant that they do not know enough to ask more than their

(*Continued on page 376*)

The Chlorination of Water*

Old and New Determination of the Dosage and Time Intervals

By Abel Wolwan and Linn H. Enslow

THE disinfection of waters by means of various forms of chlorine has been practiced in this country and abroad for many years. During this period a general theory of chlorination has grown up, particularly on this side of the water, which has had little or no scientific basis. The general hypothesis concerning the effects of chlorination, the proper dosage, and the nature of the chemical and biological reactions have been deduced from a few well-controlled experiments on waters of certain characteristics. The results of these experiments, however, have led to the universal adoption of chlorination for waters differing materially from those upon which earlier experimental data were made available. When, therefore, a number of water supplies were treated with standardized doses of chlorine, or its compounds, failures in performance were soon recorded.

In the supervision and control of a single water supply, the problem of chlorination offers far less difficulty than in the case of a group of water supplies, all of which have distinctive and disconcertingly variable qualities. The control of disinfection of a city water supply, supported by daily chemical and bacteriological examinations, may at least approach a scientific procedure, although surprisingly few cities even at this late date actually do more than a superficial dosing at a more or less constant rate. The supervision of chlorination becomes, however, a problem of major importance where a large series of supplies are to be treated under the direction of some central authority, like a State Department of Health. With 10 or 15 water supplies—inadequately sampled, some in the raw state, some just after coagulation, some filtered, ranging through every degree of color and turbidity, now free from organic material and an hour later loaded with surface wash—what form of control should be adopted? Here a speedy, safe, easy method of antecedent control, rather than of subsequent failure, is essential. On this phase of chlorination, the preliminary routine control of widely different types of waters, scientific literature, with some few exceptions, is silent.

In the state of Maryland, as in other states, experience indicates that, in general, chlorination control has been inadequately studied. When we bear in mind that a number of supplies are under the supervision of laymen, it becomes clear that consistently good results in disinfection are hardly attainable without the use of some presumptive indicator of an efficient chlorine dose. Presumptive tests of chlorine efficiency have been discussed by various students of the problem; but their contributions, although suggestive, have been based upon such meager experimental evidence that they cannot yet be considered definitive.

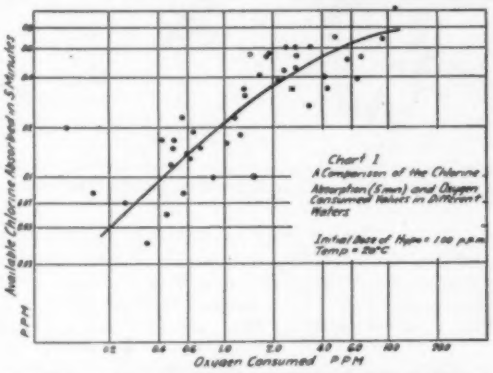
The present brief discussion is the result of a study, carried on during the past 18 months, of the application of chlorinators under variable conditions. The data here set forth are fragmentary. They are reported in order to invite attention to the extreme intricacy of the whole problem rather than as the basis of a formula designed to furnish the proper doses of chlorine and its allied compounds. It may be stated, however, that observation of the conditions in this state has served to point out a wide field for further intensive experimentation and, in this respect, the material here presented may be of some little value.

The importance of the absorption of so-called "active chlorine" by different waters is somewhat ill-defined in its relation to disinfection or the elimination of objectional bacterial life. Some experimenters assert that the amount of absorption discloses little concerning the destruction of bacteria, while others assume that the chlorine consumed in "oxidizing organic matter and sometimes ferrous salts or sulfides will not effect sterilization."[1] Since the latter assumption necessarily permits an increased factor of safety in the control of the chlorination, it is probably advantageous to use the hypothesis as a base until the collection of adequate data indicates what quantitative variations therefrom may be necessary.

In order to study the significance of the absorption of chlorine by waters, it is of interest for scientific and practical purposes to obtain some idea of the factors which influence or predetermine the losses of chlorine in different waters. Owing to the complexity of conditions under which the action of chlorination proceeds, such data as the above and any conclusions pertaining thereto may be ascertained in only an empirical manner. A few apparently elementary features of chlorine absorption, therefore, are described briefly in order to establish at least some salient characteristics of the phenomenon of the disappearance of the active agency in chlorination.

A few experiments were tried to determine the velocity of absorption of available chlorine by the same water during varying time intervals. The data were collected in order to compare with similar work reported by Race.[2] A comparison of these findings with the values reported by Race indicates that K, the velocity constant, in general, decreases with the time of contact. These values are in agreement with the conclusions noted by Race. It should be pointed out, however, that the value of K approaches a constant for different time intervals in those waters whose organic content is low. It appears, therefore, that the rate of chlorine absorption deviates from the ideal monomolecular law of chemical reaction in an increasing degree with waters of increased organic content. In other words, the monomolecular law with K constant is fairly well typified in those few waters which have only slight organic content. This is to be expected, since it is only in these latter waters that the compounds acted upon are probably of such simple chemical structure as to result in a constant reaction velocity.

The use of color readings as a presumptive indicator of the amount of chlorine which would be absorbed by a water in a given period has been suggested as a convenient procedure for routine operation of disinfectant plants. To be of any value, such readings should be the result of a long series of correlated experimental observations. Such continuous series have not been developed, it is believed, for many individual water supplies, while still less has been done in the way of comparative readings on different water supplies. Data upon this question are now being collected in this department. They are not reported in this paper on account of their insufficient number, but the evidence from the observations now available would seem to indicate that for the *same* water supply, changes in color are not necessarily concommitant with variations in chlorine absorption during a constant time interval, while for different water supplies the same conclusion is indicated as far as interdependent chlorine absorptions are concerned. It would appear, from the evidence now at hand, that color readings in different water supplies cannot be adapted to the prediction of chlorine absorption readings, because of the absence of any adequate conversion factor.


Available Chlorine Absorbed in 5 Minutes
P.P.M.
Oxygen Consumed P.P.M.
Chart 1
A Comparison of the Chlorine Absorption (5 min) and Oxygen Consumed Values on Different Waters
Initial Dose of Hypo = 100 p.p.m.
Temp. = 20°C

In order to study the variation of chlorine absorption in a surface water within different ranges of turbidity, a series of 350 samples of the Potomac River water at Luke, Md., were examined during June and July, 1918. A study of the turbidity readings and the chlorine absorption tests indicates practically no correlation whatever between these two phenomena, although the turbidities ranged from 0 to 90 parts per million. The Potomac River water at the above station offers an interesting illustration of the necessity for guarding against unwarranted correlations between the physical property of a water and its biochemical conduct. In the case of the above water, the chlorine absorption values (during five minutes) showed no increase whatever with increases of turbidity, but rather a slight decrease. That the absorption remained almost constant and even decreased, in a degree, with an apparent physical degradation of the water is probably explained by the fact that the Potomac River at the point under discussion contains considerable oxidizable mine wastes. Sudden rainfalls create dilutions of these waters, but at the same time raise the turbidity readings on the river. It comes about, therefore, that the increased muddiness in the water is in reality accompanied by a reduction in oxidizable material, without a consequent increase in chlorine absorption values. The situation is somewhat analogous to the reductions in alkalinity frequently observed with rises in turbidity. It is clear from the above situation that the direct variation of dosage with increase of turbidity would have been fallacious and contrary to the demand of the water. When the attempt is made to correlate turbidities of *different* waters with their corresponding chlorine absorptions, even less success is experienced. This situation is to be expected in different supplies, because of the variance in character and degree of watershed pollution. It may be postulated, as a preliminary conclusion, that turbidity readings are not a safe index of chlorine absorption for different water supplies, but may be adapted, with sufficient precautionary measures, to use for an individual supply. Even in the latter case, the conversion of turbidity to chlorine absorption is accomplished only after long studies of widely varying phases of the same supply.

Inasmuch as the oxygen-consumed values of waters represent approximately the oxidizable compounds present in such supplies, it would seem that this chemical index should bear some relation to the complex action of chlorine absorption, of which some portion at least partakes of the nature of an oxidation. In order to study this phase of absorption, a series of widely varying waters, of surface and underground types and of different ranges of pollution, were examined during portions of 1917 and 1918. In all of these waters the oxygen-consumed and the chlorine-absorbed (5 min.) values were obtained. These readings are graphically shown on the chart, where the individual and average values have been plotted, in order to permit of the construction of an empirical curve. The data there shown apparently disclose a fairly close variation of chlorine absorption with the oxygen-consumed values of different supplies. This correlation, it should be emphasized, is independent of the source or nature of the water, since the 45 waters tabulated include those from raw surface streams, deep wells, and filtered supplies.

The empirical curve indicates at once that the amount of chlorine absorbed in a definite time interval does not increase in direct proportion with the increase in pollution of the water (as measured by the oxygen-consumed test), but that the 5 minute rate of chlorine absorption shows a decreasing acceleration with increases in pollution. In other words, increases in oxygen-consumed values appear to result in *relative* decreases in the intervals between successive chlorine absorption values. This phenomenon is made clearer by refrence to the table, wherein are compared certain values obtained from the empirical curve shown in the chart.

Oxygen Consumed Reading	Oxygen Consumed Interval	Chlorine Absorbed Reading	Chlorine Absorbed Interval
0.5	...	0.117	...
1.0	0.5	0.211	0.094
1.5	0.5	0.290	0.079
2.0	0.5	0.350	0.060
2.5	0.5	0.402	0.052
3.0	0.5	0.449	0.047
3.5	0.5	0.488	0.039
4.0	0.5	0.520	0.032
4.5	0.5	0.550	0.030
5.0	0.5	0.577	0.027
5.5	0.5	0.600	0.023
6.0	0.5	0.620	0.020
6.5	0.5	0.635	0.015
7.0	0.5	0.652	0.017

The apparent correlation discussed above has considerable practical importance aside from its use in the chlorination of water supplies. Its probable existence may result in the development of an extremely rapid presumptive indicator of the quality of a water, namely, its chlorine absorption in a definite time interval. It has been found comparatively simple, in this laboratory, for instance, to differentiate between an underground supply of good quality and a comparatively poor surface supply, simply by means of a chlorine absorption test made in 5 minutes. The informa-

*From *Jour. Ind. and Eng. Chem.* The data submitted are the results of a study of the question of chlorination control in Maryland, upon which the writers have been detailed under the general direction of Mr. R. B. Morse, Chief Engineer, Maryland State Department of Health.

[1] Dakin and Dunham, "Handbook of Antiseptics," 1918, p. 106.

[2] "Some Aspects of Chlorination," *J. Am. Water Works Assoc.*, June 1916.

tion gained would seem to be capable of wider application to the entire field of water treatment. As a rapid diagnostic index of changes in quality of water supplies, the chlorine absorption test appears to offer a fruitful field for investigative effort.

The practical effectiveness of any chlorine treatment is necessarily measured and conditioned by its ability to eliminate the significant bacterial life in the water. The preliminary determination of a dose which may be subsequently found to be effective has been the primary objective of past investigations in this field. In practically all of these methods of presumptive testing for effective dosage, chlorine absorption tests have played an important rôle. It is of interest, therefore, at this point to review briefly several of the methods of chlorine control now in use and to discuss the principles underlying their application.

American practice in the chlorination of water supplies has always been sharply differentiated from the foreign. In general, the foreign sanitarians have employed chlorine doses appreciably higher than those in use on this continent. This policy has been the resultant of a conservative conception of the whole question of chlorination and has therefore left its impress upon the modern systems of chlorination control. A study of the various methods of presumptive tests for the effective doses discloses the common assumption, independently promulgated, that the chlorine absorption in definite intervals bears some definite but apparently unknown relation to disinfection accomplishment. This definite relationship is, however, the subject of a wide difference of opinion among individual sanitarians, with always the sharp demarcation between the foreign and domestic viewpoints.

The principle underlying practically all of the chlorination control procedures is that of measuring the amount of available chlorine absorbed by the water to be disinfected in a given period of time. To this amount a factor of safety is usually added, giving a resultant so-called effective chlorine index. It is clear that the important element in the above procedure is the time element. The time interval taken for the measurement of the chlorine absorption is dependent upon the consideration of the death rate of the bacteria under the particular conditions. A dose measured in the light of the above principle is a safe dose only if the time interval used in its evaluation is amply sufficient to provide for adequate bacterial destruction. The problem of measurement of chlorine dosage resolves itself, therefore, into the question, "What is the safe time interval for the chlorine absorption test?"

The literature of chlorination suggests various answers to this question. Adams,[2] in his discussion of the chlorination of the water for Toronto, Canada, seems to assume that 3 minutes (plus a factor of safety) is a sufficient time interval for such a test. The basis for his criterion is not apparent. He states, however, that "by conducting a series of tests it was determined that Color No. 2 represented a surplus of chlorine in the finished water that would guarantee efficiency in bacterial destruction at all times, and in the great majority of cases would not give taste or odor, and under no circumstances a bad taste or odor." Color No. 2 was equivalent to the intensity of color existing with a definite excess of available chlorine.

That such a short time interval as the above is not universally applicable is evidenced by a survey of the data reported by Race.[4] It would appear from a number of the experiments there cited that effective sterilization or even approximately fair destruction is frequently not obtained even after a 60 minute interval. The application of a 3 minute absorption test to such a condition would demand, of course, an auxiliary factor of safety of high proportions in order to eliminate the danger of ineffective dosage.

Dienert,[5] of the city of Paris, France, approaches this problem in the conservative manner suggested in the preceding statement. He not only stipulates factors of safety abnormally high in comparison with American practice, but uses in addition a chlorine absorption time interval of 15 minutes. He says:

"For the treatment of water we use always a quantity of available chlorine equal to that absorbed in a quarter of an hour increased by 0.5 p. p. m. We estimate that to sterilize a clear water with a quantity of chlorine determined as we have just said, 3 hours contact are necessary. If, for certain reasons, we are obliged to distribute water before this delay, we must increase the quantity of chlorine and bring it up to 1.00 instead of 0.5 p. p. m.

"Thus, let us take a water whose absorption of available chlorine in a quarter of an hour is equal to 0.2 p. p. m. If the water must be distributed in a very short time we would add 1.2 p. p. m. in order to sterilize it. If we should store the water longer than 3 hours, we would use only $0.2 + 0.5 = 0.7$ p. p. m. of available chlorine.

"We have established, in following the bacterial content of river or turbid waters treated with doses of free chlorine of from 1.00 to 1.5 p. p. m., that at certain moments *B. coli* was not destroyed. Safety in treatment demands the use of a dose of free chlorine a little higher than the doses given above."

Professor Santoliquido,[6] of Italy, adds to the general theory by stating that "the bactericidal action of chlorine is not instantaneous for any particular bacterium; in order that the action should result, there is always necessary a contact period, which, at a minimum, must be from 10 to 20 minutes."

Costa and Pecker[7] modify somewhat the system of presumptive test for chlorine dosage by eliminating the factor of safety and using their so-called "chlorine index." The index appears to differ but slightly, in its evaluation, from the usual chlorine absorption tests reported by other authors and in our own discussion. They establish as a principle or hypothesis that the useful dose for the purification of water is determined by the total quantity of chlorine fixed by the water in a given time and under definite conditions. They have determined, as a result of experience, that the initial dose of chlorine be used in evaluating their index should be 5 p. p. m. As to the period of contact for the test, the authors have taken the figure of 30 minutes, which they state "is generally adopted for the purification of water by chemical substances."

These authors declare further, that they have been able to decide after more than 2 years' experimental work that the sterilization of water is not very often obtained if the quantity of chlorine used does not reach the figure fixed by the index, and that these latter figures give quantities sufficient for purification.

The foregoing discussion seems to indicate the absence of any general agreement either as to the necessary time interval for the chlorine absorption test or the relative scale of factor of safety. The evidence as to the velocity of bacterial destruction under widely varying conditions is far from complete. It would seem that a 30 minute absorption plus a high factor of safety is hardly necessary. It is doubtful, too, whether such factors of safety as 0.5 to 1.00 can be universally employed under such conditions as exist in Maryland, where frequently the period of contact before consumption is so brief as to preclude a dose which would result in such excessive amounts of free chlorine at the tap.

A general survey of this phase of chlorination discloses a need for additional data regarding the velocities of disinfection under actual operating conditions. That the conceptions of this phase are inadequately developed is evidenced by the wide discrepancy in the phenol coefficients of chlorine, for example, quoted in current literature.[8]

[2] "Water Chlorination Experiences at Toronto, Canada," *Am. J. Pub. Health*, August 1916.

[4] "Some Aspects of Chlorination," *J. Am. Water Works Assoc.*, June 1916; "Chlorination and Chloramine," *Ibid.*, March 1918.

[5] "New Perfections in the Chlorination of Waters," *La Technique Sanitaire et Municipale*, February 1917.

[6] "Note on the Purification of Potable Water by Calcium Hypochlorite," Office International D'Hygiene Publique, May 1918.

[7] "The Determination of the Useful Dose of Chlorine for the Purification of Water; The Chlorine Index," *Compt. rend.*, February 1918.

[8] Rideal, *J. Roy San. Inst.*, 31 (1910), 33-45, gives 2.2, while Schneider, "Bacteriological Methods—Food and Drugs," p. 260, gives 12.5.

Latent Heat of Fusion

By Prof. W. C. McC. Lewis, M.A., D.Sc.

THE process of fusion of a solid has been investigated by Honda (*Science Reports*, Tohoku University, September, 1918) from the point of view of the quantum hypothesis. The chief interest of the work lies in the view taken of the nature of the molecular and atomic movement in the liquid or fused state of a substance. Our long familiarity with the principle of the continuity of the gaseous and liquid states, and the important results gained in this field, have served to impress physicists and chemists with the close analogy which exists between a liquid and a gas. On the basis of Honda's considerations, we are led to expect a far closer analogy between a solid and a liquid, in so far as the type of molecular or atomic energy is concerned. Let us take the simple case of a monatomic solid. Its energy consists of vibration of the atoms. On the equipartition view this energy amounts to 3 RT per gram-atom, of which one-half is kinetic, one-half potential energy. On the quantum theory this expression is modified in the sense that T itself is replaced by a complex expression (involving T), which allows for the fact that the heat capacity diminishes as the temperature falls. In both cases we restrict ourselves to vibrational movement of the atoms alone; we do not consider any other possible mode of motion. According to Honda, however, the molecules or atoms may possess small dependent *rotational* vibrations about their centres of mass, and when we approach the melting-point of the substance the amplitude of the vibration attains such a magnitude that the rotational vibration "at last becomes a continuous rotation." "As soon as the rotational vibration is changed into a continuous rotation the regular spacing of the molecules breaks down, disorder beginning to take place, and therefore the rotation becomes independent of the translation." The molecules have now two or three degrees of freedom in respect of rotation. "Since the molecular distances in the solid and liquid states do not differ much, the rectilinear motion of the liquid molecules is also vibratory, its amplitude remaining the same." The latent heat of fusion is therefore identified with the bringing into existence of the two or three degrees of freedom of rotation. Honda calculates what this energy amounts to on the basis of the quantum theory, and then proceeds to compare the result with the observed latent heats of fusion. For sixteen elements he finds very satisfactory agreement. In six other cases there is no agreement, and this he explains on the basis of the external and internal work done owing to the change in volume on melting. Honda has also applied his ideas to the fusion of compounds, and finds in certain cases that a similar relation holds good. "It is necessary to assume that these compounds have a molecular structure both in the liquid and the solid, and that in the liquid state the molecules have three degrees of freedom for rotation." In other compounds it is necessary to assume a number from 3 to 6 for the degrees of freedom in order to bring the calculated and observed latent heats into agreement. It is evident that Honda's views are not as applicable to compounds as they are to elements. Nevertheless, the importance of the contribution as pointing the way to an explanation of the mechanism underlying the process of fusion is very considerable.—From *Science Progress*.

Airplane Wing Design

Continued from page 367

rush of the atmosphere. It acts as if there were a downward component of motion in the air around the wing, of very much the same amount that might be calculated from the strength of its own trailing vortices. This is manifest in a relatively poor lift, as if something were reducing the angle of attack, and in a greater resistance as if climbing up through a descending wind.

(*h*) LAWS OF ENERGY CONTENT IN TRAILING VORTEX

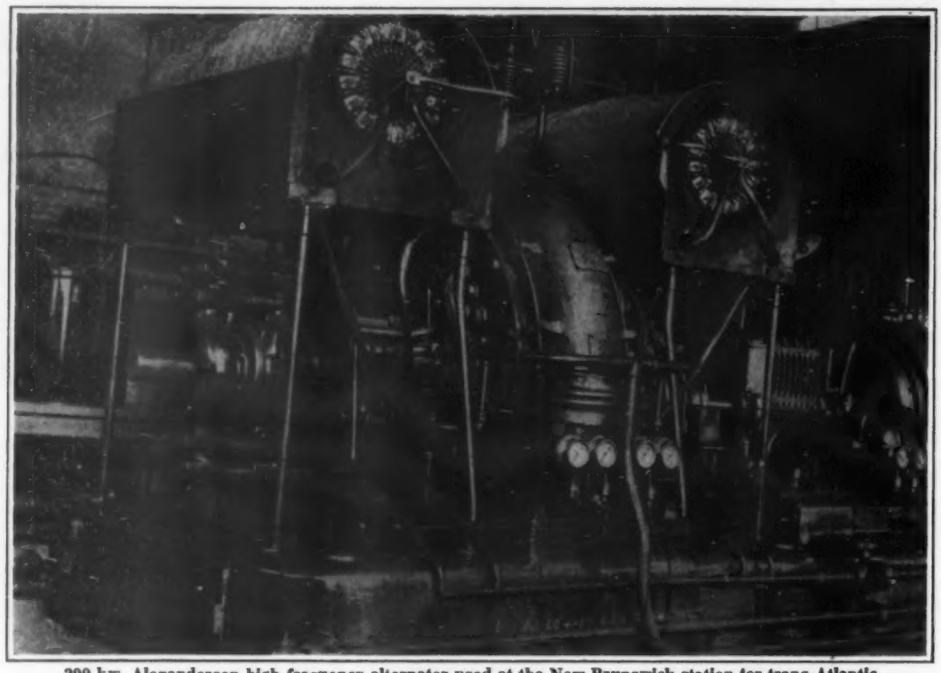
Mathematically it would appear to be as easy to calculate the energy of vortex-motion lift in the wake of an airplane as it is to calculate electrical self-inductance. The arrangement of trailing vortices behind an airplane evidently depends considerably on the distribution of the loading along the wing span, because a wing can terminate in effect considerably short of the actual tip by an easing up of the lift. Calculations concerning the best arrangements would be interesting. The writer has made some approximate computation by assuming the trailing vortices to be a group of parallel columnar vortices: a sort of vortex sheet constituting the wake of the wing. This method of calculation applied to a monoplane gives the usual values of the lift-drag ratio when friction is taken into account.

(*i*) FRICTION AND HEAD RESISTANCE

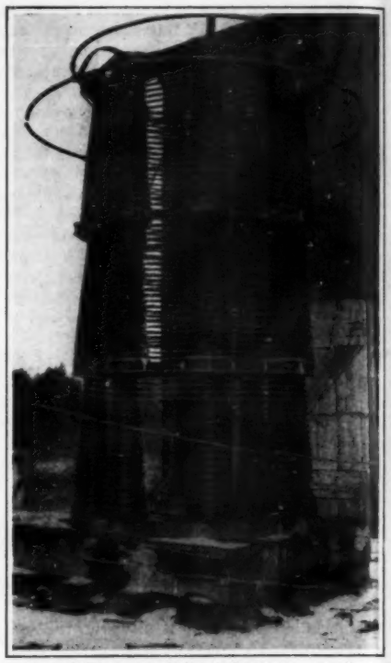
In a practical way friction is a very large item and it would be very interesting to have separate tests for the friction losses of wings. For example, tests might be made of the resistance of a hoop or endless ring having the cross-section of a good wing.

(*j*) EXPLOSION OF EDDIES

Frequently the low pressure at the center of a vortex or eddy in real air appears to be penetrated by a rush of air along the axis. Knowledge about this, especially with reference to the effect, cause and control of such disturbances in the wake of wings, would be interesting.



200 kw. Alexanderson high-frequency alternator used at the New Brunswick station for trans-Atlantic communication



One of the transmitting inductances used at the New Brunswick station

Experimental Wireless Telegraphy and Telephony—XI*

Principles of Undamped Wave Transmitters and the Wireless Telephone

By Louis Gerard Pacent and Austin C. Lescarboura

UNDAMPED oscillations are not broken up into groups like damped oscillations. Exactly similar current cycles follow one another continuously, except as they are interrupted by the sending key, or subjected to gradual fluctuations of intensity as when used in radio telephony. Undamped oscillations are produced by a high frequency alternator, an arc, or vacuum tubes.

The main advantages of undamped waves are the following:

(1) Radio telephony is made possible. (2) Extremely sharp tuning is obtained and consequent reduction of interference between stations working close together. A slight change of adjustment throws a receiver out of tune, and the operator may pass over the correct tuning point by too rapid a movement of the adjusting knobs. (3) Since the oscillations go on continuously instead of only a small fraction of the time, as in the case of damped waves, their amplitudes need not be so great, and hence the voltages applied to the transmitting condenser and antenna are much lower. (4) With damped waves the pitch or tone of received signals depends wholly upon the number of sparks per second at the transmitter. With undamped waves the receiving operator controls the tone of the receiving signals, and this can be varied and made as high as desired to distinguish it from strays, and suits the sensitiveness of the ear and the telephone. These advantages, freedom from interference and from other stations through selective tuning, the use of high tones and low

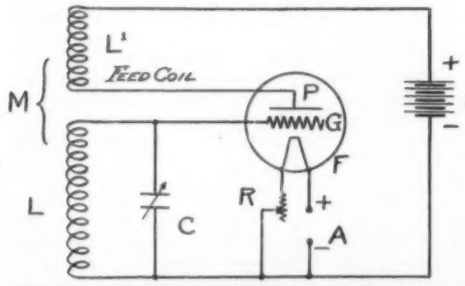


Fig. 1. Arrangement of circuit for producing oscillations with a vacuum tube

voltages, and the greater freedom from strays combine to permit a higher speed of telegraphy than could otherwise be obtained.

*This is the eleventh instalment of a series that has appeared from time to time in the SCIENTIFIC AMERICAN SUPPLEMENT, beginning with the issue of July 5th, No. 2270. Back numbers may be obtained as long as the supply holds out.

METHODS OF PRODUCING UNDAMPED OR PERSISTENT WAVES

Persistent, continuous or undamped waves, which ever way one wishes to designate them, can be generated by several distinct methods, each having its advantages and disadvantages as follows:

(1) The arc or Poulsen method of obtaining oscillations of radio frequency by means of an electric arc burning in an atmosphere of hydrogen and in a strong magnetic field. The arc method produces undamped waves of rather long wave length, and is ordinarily operated on 500 volts direct current. It has been discovered than an electric arc between proper electrodes

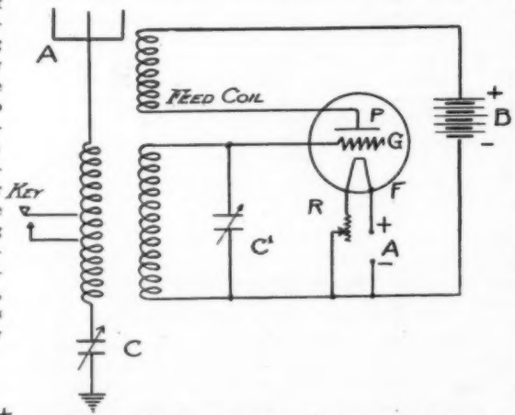


Fig. 2. Simple hook-up for using a vacuum tube as an undamped wave transmitter

shunted by an induction coil and a condenser will produce undamped oscillations through the shunt circuit, and such a circuit is used to excite an aerial circuit for transmitting purposes. Depending on whether a key or a telephone microphone is used, the arc generator may be arranged for radio telegraphy or radio telephony. For radio telephony a microphone may be inserted in the ground wire, if it is capable of carrying the antenna current. The vibrations within the microphone caused by the sound waves alter the resistance and modify the radio oscillations and transmitted waves.

(2) The high frequency alternator method, which is practically an inductor type of alternating current generator having a great number of poles and revolved at high speed in order to obtain the frequency desired. A standard General Electric Alexanderson 2-kilowatt high frequency alternator designed for a frequency of 200,000 cycles or 1,500 meters wave length is revolved at a speed of 20,000 revolutions per minute.

The rotor consists of a steel disc with a thin rim and much thicker hub, shaped for maximum strength. Instead of having teeth on the edge, it is slotted with little windows, the inductors in the form of spokes, and leaving a solid rim of steel. Then to cut down the air friction the slots are filled with non-magnetic material such as phosphor-bronze, finished off smoothly with the face of the disc. These machines embody a number of novel features made necessary by the small space per inductor and the exceptional speed. Their construction became possible only through engineering skill of a very high order and by fine workmanship. They are only suited to big commercial and government installations of a permanent character.

(3) The Goldschmidt alternator method is somewhat complicated as it generates persistent waves through the multiplication of a relatively low initial frequency by means of a series of electrical reflections between the stator and the rotor of the machine. For example, an alternating current of say 10,000 cycles is put through the stator, and the rotor is tuned to the frequency of the stator. The resultant frequency will be twice the initial frequency. The latter frequency is put through another oscillating circuit tuned to its frequency and the result is again a considerable multi-

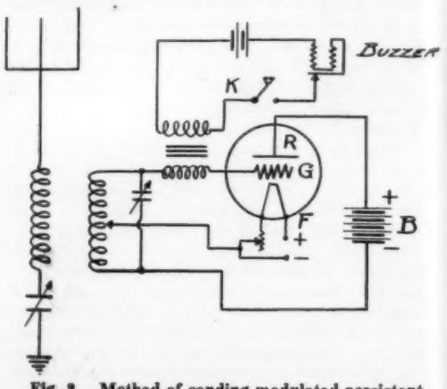


Fig. 3. Method of sending modulated persistent waves, by means of transformer and buzzer

plication. The last frequency can then be connected with the antenna and ground through a proper loading coil.

The large Goldschmidt generators used in trans-At-

lantic service have 360 poles and are driven at 4,000 revolutions per minute by 250-horsepower motors. The fundamental frequency is therefore 12,000, which is quadrupled as has just been explained, giving 48,000

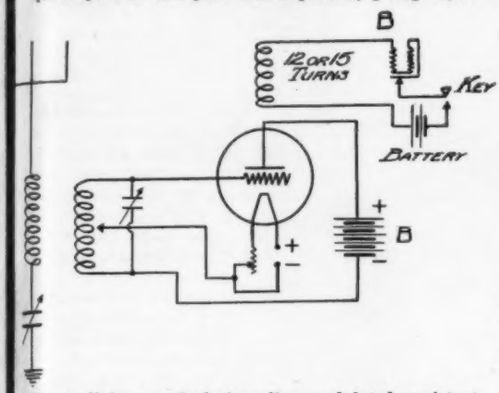


Fig. 4. Unique method of sending modulated persistent waves by having a coil or inductance on the outside of the vacuum-tube bulb

at the antenna. To secure satisfactory operation the finest sort of workmanship is necessary in building them.

(4) Frequency transformer method, which is accomplished by using a series of transformers in each of which the initial frequency is multiplied by two. Current is generated by an alternator at a relatively low frequency (10,000 cycles per second or less) after which the frequency is increased to 30,000 or 40,000 cycles by two groups of transformers and so on until the proper frequency is obtained.

(5) The vacuum tube oscillator method, which is caused by using the Armstrong "feed back" system of regeneration. This is accomplished by placing an inductance in series with the plate and this, in turn, is placed in inductive relation with the grid, causing the plate current to act on the grid and producing oscillations of a frequency dependent entirely on the constants of the circuit. Fig. 1 shows this arrangement in simple form, and can be followed in experimenting along these lines. The action is not unlike the howl that is produced when a telephone receiver is placed directly over the transmitter mouthpiece.

The experimenter is practically limited to the vacuum tube for his experiments and work with undamped waves because of the cost of the other methods. Even leaving aside the consideration of cost, in most instances the undamped wave generators other than the vacuum tube operate best on long wave lengths which are barred to amateurs. However that may be, the fact remains that the vacuum tube makes an excellent generator—one that is quite flexible, too, since its power can be increased merely by connecting more bulbs in parallel.

Fig. 2 shows a method of connecting a vacuum tube generator to an antenna for transmitting undamped or continuous waves. The key, it will be noted, is placed

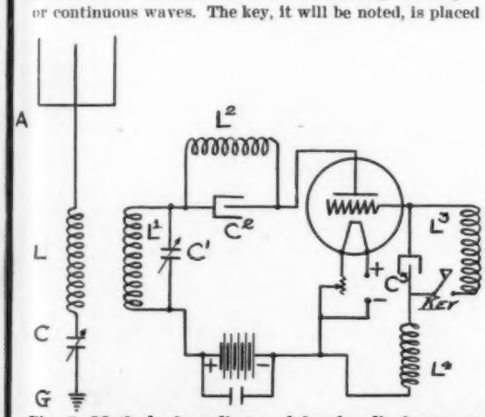


Fig. 5. Method of sending modulated radio-frequency current

across a couple of turns of the secondary of the oscillation transformer, so that the set is tuned and detuned with the operation of the key. It will be recalled that the sharpness of undamped waves is quite marked at the receiving end, so that it follows that when the set is detuned, even to the extent of two turns of the secondary of the oscillation transformer, the waves are not heard at that moment. In this manner it is possible to make dots and dashes with an ordinary telegraph key, even when handling considerable transmitting power, since little power is broken by the contacts.

Fig. 3 shows a method of transmitting modulated persistent waves by having a transformer in the grid circuit and a buzzer and a key in the primary winding of same. The note emitted is similar to the tone of the buzzer used, and such signals can be received on any type of receiving set as distinguished from the straight undamped waves which cannot be heard with the ordinary crystal detector working in a damped wave receiving circuit.

Fig. 4 shows an unique method of transmitting modulated persistent waves by having a coil or inductance placed close to the vacuum tube as indicated, so as to modulate the electron current in the bulb. The tone emitted by such a transmitter is that of the buzzer used. Fig. 5 shows a method of sending modulated radio frequency current. In this arrangement advantage is taken of the tube because it is made to generate both audio and radio frequency current at the same time. The radio frequency circuits are L and L^1 and C and C^1. There is coupling between L^2 and L^3. The circuits L^2 C^2 and L^3 C^3 are in resonance and the note emitted may be varied at will by varying the constants of their circuits. An inductance of 50 millihenries and a capacity of 2 microfarads will give a 500 cycle current with such an arrangement.

Radio telephony can be accomplished by employing any of the methods of producing continuous waves already described, providing that a suitable method is used to vary the power in accordance with the sound waves emitted by the speaker.

The principles of radio telephony are the same as those of radio telegraphy by undamped waves, except that the sending key is replaced by apparatus which varies the sending current in accordance with the frequency of the voice sound waves. The sound waves have a frequency much lower than the radio frequency, so that each sound wave lasts over a considerable number of radio alternations. The radio wave is thus transmitted in pulses, and is received on any ordi-

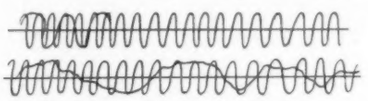


Fig. 6. Method of sending modulated undamped waves in accordance with sound waves for wireless telephone purposes

nary apparatus used for receiving damped wave radio telegraphic signals.

The power generated in the sound waves generated in ordinary speech is relatively very small, perhaps 0.00000001 watt, yet this must be made to control a kilowatt or more of radio frequency power in long distance radio telephony. The effect of the sound waves must therefore be amplified. The usual method of voice modulation is to introduce special microphones directly into the antenna circuit. An ordinary microphone transmitter can carry but 0.2 ampere of current involving power consumption of only 2 watts, without injurious heating. In order to control considerably greater quantities of power, various modifications have been used. For example, Lorenz used as many as 25 microphones, joined in parallel, Fessenden developed special water-cooled microphones, Egner and Helmstrom used oil cooling, Marzi a microphone with a moving stream of carbon grains, Chambers and also Vanni microphones in which the varying resistance was supplied by a stream of conducting liquid impinging upon the vibrating diaphragm.

But for amateur requirements, where the power employed is rather limited, there is little difficulty in attaining the proper voice modulation. In the short-distance radio telephone transmitters an ordinary telephone microphone handles the aerial current. Fig. 6 shows the manner in which undamped waves, such as those generated by an oscillating vacuum tube, are modulated by speech. Fig. 7 shows a method of modulating undamped or continuous waves by the grid method. Fig. 8 shows a combination radio telephone and telegraph set, a separate modulating tube being used in this case. The modulation of the antenna current is secured by applying the voltage variations produced by a telephone microphone to the grid of a controlling tube, the output of said tube affecting or modulating the oscillations in accordance with the sound waves.

Physical Properties of Molybdenite

THE U. S. Bureau of Standards has recently published a bulletin (No. 338) on "Some Optical and Photoelectric Properties of Molybdenite" by W. N. Coblentz, Associate Physicist, and H. Kahler, Laboratory Assistant, of the Bureau.

The following is a summary of the paper:

The present paper gives data on the change in the electrical conductivity of molybdenite when exposed to thermal radiations of wave lengths extending from wave length $\lambda = 0.36\mu$ in the ultra-violet to beyond $\lambda = 9\mu$ in the infra-red.

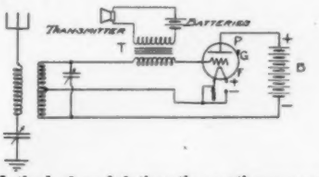


Fig. 7. Method of modulating the continuous waves by the grid method

The radiations of wave lengths extending from the ultra-violet to about 3μ produce a change in the electrical conductivity of molybdenite. The effect of temperature, humidity, intensity of the exciting light, etc., upon the photoelectrical sensitivity of molybdenite was investigated. Atmospheric humidity does not affect the shape of the spectral photoelectric sensitivity curve.

The effect of increasing the itnensity of the exciting radiations appears to be to produce a more rapid response in the long wave lengths than in the short wave lengths, with a resultant shift of the spectral photoelectric sensitivity curve toward the long wave lengths.

There is no simple law governing the variation in the photoelectric response in molybdenite, with variation in intensity of the radiation stimulus.

At room temperatures there are maxima of sensitivity in the region of $\lambda = 0.7\mu$, 0.85μ, 1.02μ, and 1.8μ. Beyond 2.5μ the photoelectric sensitivity is nil.

Raising the temperature causes a rapid decrease in the spectral photoelectric sensitivity, especially in the regions of 1.02μ to 1.8μ. At 80 C. the spectral photoelectric sensitivity has practically disappeared, only slight indications being observed for radiations of wave lengths $\lambda = 0.6\mu$ to 0.8μ.

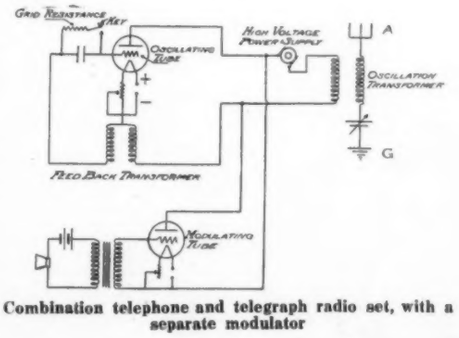
The effect produced by lowering the temperature is to greatly increase the sensitivity curve throughout the whole spectrum from the ultra-violet to 2.5μ in the infra-red. This increase in sensitivity is greatest in the region of 0.8μ to 0.9μ, so that at the temperature of boiling liquid air the maximum sensitivity occurs at about 0.85μ, with a new band at 1.25μ to 1.35μ. Samples of molybdenite which are quite insensitive at room temperatures become fairly sensitive, photoelectrically, at — 178° C. At low temperatures the spectral photoelectric sensitivity curves of all samples are quite similar, with a maximum in the region of 0.8μ to 0.9μ. From this it would appear that this photoelectric property is one of degree rather than one of quality. The fact that the bands at 1.02μ and 1.8μ occur together, and that the 0.85μ band may occur alone suggests the possibility that they are characteristic bands of spectral photoelectric sensitivity of different sulphur compounds of molybdenum.

Using frequency instead of wave length to indicate the spectral position of the radiations which cause the maximum change in electrical conductivity, it is found that in some instances there is a constant difference of the wave numbers analogous to the series relations of spectral lines.

The time required for recovery of equilibrium in electrical conductivity is twice the time of exposure.

Mechanical working of the material appears to lower the photoelectric sensitivity.

There appears to be no close connection between photoelectric sensitivity and current rectification in molybdenite.



Combination telephone and telegraph radio set, with a separate modulator

Measurements of reflecting power show that molybdenite has a high reflectivity in the violet, which decreases to a uniform value beyond 1μ. Similarly, the transmission is high and uniform beyond 1μ in the infra-red. Using these data refractive indices were computed, indicating a value of $n = 3$ for wave lengths greater than 1μ.

Future Internal-Combustion Engines—II*

Physical Processes, Mechanical Methods, Energy Utilizations, and Possible Improvement of these Motors

By Prof. C. A. Norman, Ohio State University

[Concluded from Scientific American Supplement No. 2290, for December 13, 1919]

It may not be clear to all why sustained combustion should not give as good results as more explosive combustion. The following explanation is given simply as an illustration of molecular reasoning. Molecular velocity is transformed into piston velocity, i. e. useful work, by expansion. The more a gas expands after heat has been imparted, the more of that heat will be transformed into work. It is therefore desirable to impart as early in the stroke as possible so as to make it convertible into work by the maximum amount of remaining expansion. Heat imparted late in the stroke wil have a much smaller chance for conversion and will therefore be imperfectly utilized.

INJECTION ENGINES.

A great deal of very energetic work is at present being done in the United States on various forms of injection engines. The most startling development in this field is, however, the adaptation of the German Junkers engine to aeronautical purposes. This is a two-cycle engine using two pistons working in opposite directions in the same cylinder and uncovering two sets of ports at the end of the stroke. Scavenging air enters through one set and sweeps the combustion products out through the other. The engine is consequently valveless except for the injection valve.

This, however, is the difficult part in all injection engines. At high speeds and comparatively small dimensions, the dimensions of the injection valve become minute and mechanical injury is to be expected. With injection without high-compression air the exact shape of the valve to produce a good spray is a matter of tedious and painstaking experimentation. Complete combustion of a fuel injected in liquid state is at high speed, also not easy to secure. With injection air a multi-stage air compressor is necessary. Means of obviating this has been proposed, for instance by Higgins, although at the expense of delayed ignition.

For aeronautical uses, where special fuels even at a somewhat increased price will never be a serious consideration, I have proposed and to some extent tried a partial evaporation by the exhaust heat of the gasoline before injection and at injection pressure. This would insure both an increase in the volume of the fluid and a very much more energetic mixing after injection without any intricate shapes of valves.

The injection engines deserve the greatest attention from inventors with ingenuity as well as especially from development men with a great deal of patience and detail care. A combination of the work at both might lead to the development of some very efficient as well as rugged and dependable engines for automotive uses.

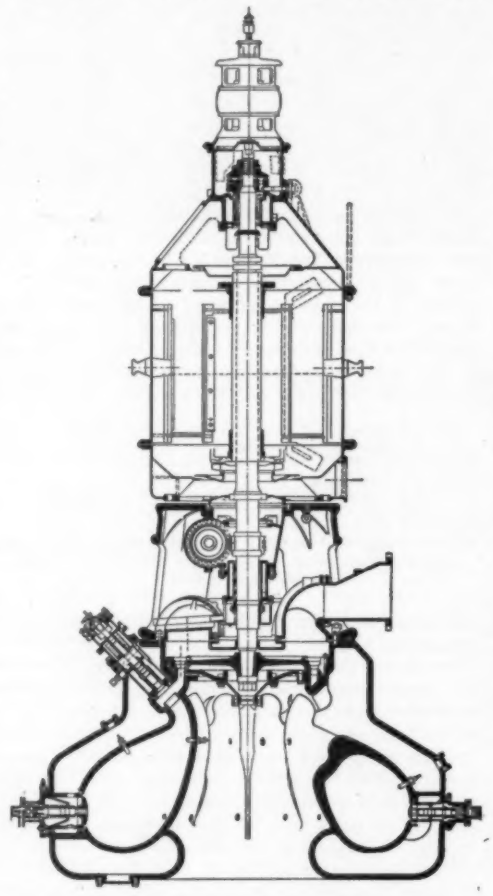
With solid-injection engines it might be of interest to study the effect of air heating by the exhaust. Even if the power were reduced somewhat, which is questionable a more rapid and perfect combustion might very well give an improvement in fuel economy more than counterbalancing this disadvantage.

EXPLOSION TURBINES.

In explosion turbines the inefficiency due to inadequate expansion does not inherently obtain. The mixture is drawn into an explosion chamber and exploded, whereupon the gases expand through a nozzle and impinge upon a turbine wheel. A section of a turbine of this character actually built and operated by Holzwarth in Germany is shown. The turbine is vertical and integrally connected to a generator. The design is both ingenious and graceful.

Owing to the impossibility of expanding to atmosphere this turbine would, if the process otherwise were exactly the same as in the reciprocating engine, have a theoretical energy utilization of about 67 per cent, the presure and temperature conditions taken to be those assumed before. Actually the process is not exactly the same. The compression cannot take place in the explosion chamber itself, but must be furnished by an outside compressor. This, on account of the added delivery work, increases the compression work theoretically about 40 per cent, practically on account of much greater inefficiencies very much more. If we use turbo-compressors their adiabatic efficiency will even for very large sizes hardly reach 75 per cent. The delivery in the combustion chambers will, on account of turbulence losses, reduce this efficiency at least 5 per cent more. Moreover, looking aside from some theoretical differences, a turbine wheel operating with a falling pressure cannot be efficient; 60 per cent is a high estimate for the efficiency of such a wheel. Making these allowances, the thermal efficiency of the turbine drops from a theoretical one of about 67 per cent to a practical one of 13.8 per cent.

This shows the danger of working with half understood formulas and generalizations. A very great number of inventors with very good engineering education,



Sectional elevation of the Holzwarth vertical explosion turbine

yet not capable of detailed analysis, have fallen in the following snare: Their theoretical text-book formula shows an energy utilization of 67 per cent. Now, they reason, there is not a single piece of apparatus in my machine that has not an efficiency of over 50 per cent. Consequently the whole machine ought certainly to have a utilization of $0.50 \times 0.67 = 33.5$ per cent. Actually the situation is that two people are eating into a pie from both sides. If both are entitled to one-fourth there should theoretically be one-half of the pie left. But if both eat twice as much as they are entitled to, that does not mean that there is going to be only half as much pie, or one-fourth left. It means that there is going to be nothing left at all. Similarly, a compressor may require theoretically only 25 per cent of the expansion work of the expander, leaving 75 per cent net. If the compressor is 50 per cent efficient, it actually, however, requires $25 \div 0.50$, or 50 per cent. If now the expander is also 50 per cent efficient it will actually yield only 50 per cent expansion work and the compressor will take it all.

This is the tragedy of the gas turbine situation and was the tragedy especially of the much heralded German Holzwarth. He succeeded in getting money to build a plant. The wheels turned, and, mechanically, the plant was quite a success. But the utilization did not come out, in fact, only a small fraction of it. Then Holzwarth wrote a beautiful book proving mathematically that while the utilization had not come out yet, it was bound to come out in time. In response to this the grand old man of turbine theory, Stodola, proved that while Holzwarth's formulas were all right individually, they were all wrong when put together, and that in consequence his turbine would never meet expectations. An energy utilization of 13 to 15 per cent was all that could be expected of it. For the turbine without an auxiliary steam plant, I incline to the same belief from an entirely different method of reasoning.

Many inventors have tried to dispense with compression in gas turbines entirely. Even Holzwarth proposes the use of an exhauster to draw gas into his combustion chambers. He actually did use a low-pressure compressor. This exhauster, or compressor, he intended to drive by steam raised on the exhaust of the turbine. As a matter of fact it is not altogether impossible that utilizations of around 20 per cent may be thus obtained. However, an explosion turbine is, if anything, a more complex machine than a reciprocating engine, and, if it needs an extra steam plant for its operation, only very unusual fuel economies could justify its adoption. As a matter of fact, a straight steam plant can be made to give an efficiency over 20 per cent and run on coal. So the commercial prospects of the explosion turbine do not seem alluring.

GAS TURBINES FOR AERONAUTICAL PURPOSES.

Whele there are no immediate prospects of gas turbines suitable as prime movers for aeronautical purposes, an interesting application has been made by Rateau of a gas turbine running on the exhaust of an airplane engine. This gas turbine utilizes the expansion of the exhaust from ground level pressure to the lower pressure at high altitudes to compress, by a centrifugal compressor, the combustion air from the altitude pressure to ground level pressure. The mean effective pressure of the engine is thereby maintained at all altitudes.

The temperature of the air at high altitudes is not much above freezing, say 500° F. abs. or 40°F. This temperature will be carried by compression to something like 600°F. absolute. The exhaust gases have easily three times this temperature. They could therefore deliver theoretically more than three times the compression work necessary to compress the air. In practice this means that the compression can be carried out if the efficiencies of turbine and compressor do not drop much below 60 per cent. Such an efficiency can be obtained. The weight of the outfit has, however, so far made its usefulness questionable.

PRESSURE PRODUCTION BY BOILING.

De Laval has experimentally run a boiler at a pressure of 2,000 lb. per sq. in. The temperature of saturation at this pressure is 640°F. Cold rolled steel has, however, at 1,000°F. still an elastic limit of 30,000 lb., and Monel metal, rolled or cast, an elastic limit well over 20,000 lb. per sq. in. There would, therefore, be no difficulty in running a boiler with small tubes at 2,000-lb. pressure and 1,000° temperature. Our data regarding the behavior of water and steam at these high pressures and temperatures in the neighborhood of the so-called critical conditions where liquid and vapor melt into one are incomplete and an investigation would be of interest. Practically it would in any case hardly pay to run pressures up to 2,000 lb. We ought, however, to carry our temperatures to the highest possible limit to utilize fully the molecular velocities in our combustion gases. At all attainable steam temperatures the main part of the velocity energy in the gases is simply absorbed in "knocking" the water molecules out of the liquid, a far smaller part goes to accelerate them. This latter part is the only one we utilize in our engines.

The higher the steam temperature, the greater is this part, the better the energy utilization. Ferranti in England has run a high superheat condensing steam turbine which gave an energy utilization of 24 per cent, disregarding boiler losses. We have boiler systems in which these losses amount to less than 10 per cent. This is the case with the surface combustion boiler of Professor Bone, combined with an economizer. By careful application of the counterflow principle so as to absorb all possible fuel heat in feed water heating, the heat losses in any boiler can be reduced below 20 per cent. All told, there should be little difficulty in de-

*Reproduced from *Journal Society Automatic Engineers*

veloping a steam plant for automotive uses which would give as good an energy utilization as the ordinary explosion engine, but do it on almost any kind of fuel.

This, in my opinion, is the most immediate duty especially of the tractor and truck engineer. With half the energy spent on boilers that we have been spending on carbureters we should probably have had an excellent safe and reliable high-pressure, high-superheat boiler long ago. It is probably coming pretty soon now and we shall be all the better for it. The next problem will then be to adapt it to the cheapest kinds of fuel. A non-condensing automotive steam plant can never be made to secure the energy utilizations that we obtain now with our best airplane engines, still less the economies we hope to obtain with improved apparatus later on. On the other hand we can never hope to inject solid or gritty fuel, hardly even very low-grade liquid fuels into our automotive internal-combustion engines. These fuels should be handed over to steam plants.

Regarding the dependability, power and maneuvering facilities of the steam engine, nothing need be said.

The fatal influence of compressor inefficiency on the prospects of the gas turbine has led many inventors to cast about wildly for a way to create a pressure difference by condensation of the combustion gases. Nothing more need be said about this just now.

POWER BY ELECTRICITY DIRECT FROM COMBUSTION.

I shall deal here with possibilities of a character entirely different from our present methods of power production, possibilities at present existing as scientific possibilities only, yet perhaps no less definitely established and understood than the principles of wireless telegraphy were established 25 years ago. For let it be clearly understood that Marconi could not have achieved wireless telegraphy if the underlying physical phenomena had not been investigated and cleared up by scientific researches of the most abstruse character in the preceding 30 or 40 years.

This is something that should be emphasized especially to an organization of American engineers. We are altogether too prone in this country to see all our salvation, all progress in "hard-headed" comon sense, in business organization and hustling and bustling methods. We are apt to forget that the practical gas engine was developed by a doctor of philosophy, that the steam turbine was also, that the Diesel engine was initiated by a doctor of philosophy, and lastly that the pioneers in flying in this country were first a doctor of philosophy and then a pair of men who according to general information were notorious dreamers and had the peculiar idea of learning to study German literature on the subject before they started out.

You cannot initiate great new lines of progress simply by imbibing a lot of current practical information and then going out and hustling. You have to get down to fundamentals, to underlying principles, check up current practice against fundamentals, and if you find that current practice embodies underlying principles, poorly, then have the courage to strike out on new paths and stick to these paths through thick and thin, with the assurance of having all the "hard-headed" business men and all the "common sense" crowd against you. All this involves leisure and time for thought and study. If we as engineers are willing to give competent scientifically trained men the time and the means to conduct investigations into the outlying fields of science, entirely unhampered and without any expectations of immediate returns, then we shall most assuredly in time see great things happen. If we are not willing to do that, we shall continue to see the far poorer countries of Europe, nations with certainly no more native intelligence than ours, continue to take the great steps in advance in many lines, leaving to us only the minor changes and problems of mass production.

Now then, simply as an illustration of one thing that might be accomplished if we give the means to the scientists, the production of electricity directly from combustion might be cited.

It is well known that a substance subject to electrolysis transports through the solution and delivers at the electrodes a perfectly definite quantity of electricity per unit weight. To drive the substance through the solution a perfectly definite electric tension is necessary. The product of the tension and the electricity transported is the work done, the product of the tension and the electricity transported per second is the power consumed. So exact is the law of the electric transport that, as we all know, the most exact means for measuring a current is to weigh the amount of silver it deposits per unit time out of solution of a silver salt. Not only does this law hold for electrolysis, it holds just as well for primary batteries. If in such a battery, say, zinc is dissolved in an acid, the zinc carries with it into the acid a certain well-defined amount per unit weight of positive electricity and an exactly equal amount of electricity will in the due course of transport be delivered at the positive pole of the element. The force that causes this transport is the chemical forces between the atoms and the electrons which cause the metal to go into solution.

In ordinary combustion the chemical force draws the atoms into collisions and our problem is to utilize for power purposes the velocities resulting from these collisions, an extremely indirect and unsatisfactory way of using the chemical force.

In electrical batteries the chemical force is used directly to drive electricity into a solution and from the solution out into a pole plate again. From this pole it may be carried into an external circuit and there be used for instance to drive a motor. The percentage of the chemical force that is delivered to the motor is dependent only on the resistances to the electric transport in the battery and in the circuit. These resistances can be kept quite low.

The question now arises: Would it be possible to use the combustion process with our ordinary fuels to deliver electric current in a primary battery, and what would be the fuel utilization of such a battery?

Answering this, we can only state here that as long ago as in 1910 and 1912 some German scientists, notably Baur, Taitelbaum and Ehrenberg, had succeeded in combining such fuel batteries using fuels ranging from hydrogen to sawdust. Electromotive forces close to the theoretically possible ones were obtained. Burning carbon electrodes, Baur obtained considerable currents without reduction of electromotive force.

The Sense of Direction in Animals

(*Continued from page 363*)

In numerous simpler cases, however, a single intermediate sign of direction is sufficient to make possible the indirect orientation, for instance, in case this sign of direction continues as a stable complex from the starting point to the goal. For example, this is the case when an ant path at the foot of a wall runs along the wall to a bush covered with plant lice. It is clear that such a uniform complex . . . leaves behind it a one-phase engram-complex in distinction from the many-phased differentiated complexes upon which genuine successively associated memory of locality is based.

We may say that this one-phase orientation by means of the wall is "channelized." Into this class of *channelized orientation* must fall all those cases in which orientation moves along a previously indicated road. This includes not only beaten roads, but all sign posts and local signals of every description including footprints, odors and definite topographical lines such as walls, the shores of streams, etc. The common factor in all these cases consists in the circumstance that the orienting one-phased stimulus-complex concerned is in the immediate vicinity of the receptive sense apparatus (organ of sight, smell, or touch), so that even a slight deviation to one side will take the animal outside the domain within in which the said stimulus operates, and will, therefore, cause it entirely to lose the direction.

The case is quite different in those instances in which the source of the stimulus is at a comparatively infinite distance from the receptive organ. Typical examples of this are orientation by means of a compass, or by the sun or stars. The comparatively infinite distance of such stimuli demands, on the one hand the ubiquity of the stimulus currents proceeding from them, and on the other hand it requires that the latter shall travel (within practically infinite distances) in parallel lines to all the points reached. In consequence of this even a very great lateral deviation (as when an animal is carried a long distance to one side of its path) is obviously incapable of altering the absolute direction. Thus an animal which has been forced to deviate from its path will hold to its original course (as a ship directed by a compass); in other words, it will follow an "apparent" or "virtual" orientation (Santschi)[13] whose absolute direction will be exactly parallel to the original direction. . . . It follows from this that such a so-called "free" orientation (in contrast to a channelized orientation) will remain an actual orientation with respect to a definite goal, only so long as the spacial-kinetic continuity of the journey is strictly maintained.

One other important phenomenon may be mentioned. We have seen that in the case of indirect orientation based upon many-phased complexes, the relative direction results inevitably from the direction of the series of the various intermediate complexes. This cannot be true naturally in the case of one-phased orientation, since in this instance there is either only one complex present or if there be a succession, such, for example, as in a continuous series of foot-prints, the successive single complexes are entirely uniform. . . . As a matter of fact we find that in all cases in which a one-phased complex makes possible an inevitable relative plan of direction the stimuli concerned are localized a-symmetrically upon sharply defined areas of the sense organs, so that upon the return trip there is a sensory reversion to the corresponding area upon the other side, i. e. to that area of the sense organ which is diametrically symmetrical. . . . In the example mentioned above of the ant path along a wall, all of the ants going from the nest to the colony of plant lice touch the wall with the right antenna and see it with the right eye; on the return trip they receive the complex with the corresponding sensory area upon the other side of the body. It is obvious that if they associate this constant a-symmetrical localization with the corresponding engram of the goal, they must come to know the difference between the two directions running from the nest to the colony and vice versa. But assume for the moment that the path runs between two exactly similar walls. In such a case the sense organs on the right side and on the left will receive identical and symmetrical impressions, which will not permit such a reversion as above described. Hence if an ant were removed from such a path and after the lapse of some time returned thither, it would doubtless be incapable of deciding as to the relative direction of the nest and the colony. . . . The same principle holds good in all other one-phased orientation complexes, whether channelized or free: an orientation by means of the compass or of a distant source of light will always be identical with regard to the relative direction: if on the other hand two sources of light were present at precisely symmetrical locations, or, if the north and south signs failed to be marked on the compass then the orientation could be determined only with respect to the absolute direction of its axis. A trail of footprints or a path marked by red arrows presents an orientation complex whose separate direction marks are polarized as far as the senses are concerned; but if the path were marked merely by exactly similar red lines instead of by arrows it would evidently be of no value as regards a relative instead of an absolute sign of direction. In the same way a completely homogeneous scent-trail exactly similar as to its minutest chemical particles upon every portion of the way would be incapable of producing a *relative* sign of direction.

* * *

General Conclusions.—As far as the nature of the stored up engrams upon which indirect orientation is based is concerned it is quite clear that these must consist essentially of the memories acquired during the individual life. In the case of many-phased orientation, i. e., differentiated locality memory, this is obvious since the position of the nest in which the various generations are born is subject to continual change within the course of a few years or a few decades. But even in the one-phased intermediate complexes each individual must usually (and often indeed for each separate journey)[14] acquire a special engram, even if the disposition to orientation according to one or another intermediate complex (for example according to the sun) may be capable of being fixed by heredity. . . .

The biological significance of the capacity for indirect orientation is very obvious: in the case of the animals which wander about freely without any fixed dwelling place direct orientation is, of course, entirely sufficient for the accomplishment of all the necessities of life. But things are quite different in the case of the nest-building animals and especially so in that of the social animals. Among these the capacity of indirect orientation is a necessary condition of existence, in consequence of the necessity they are under of returning to a definite dwelling place after all their expeditions. It can be proved, consequently, to exist in all such cases without exception, though frequently in its most primitive form.

The work done by indirect orientation based upon individually acquired engram associations naturally requires much more brain substance, or to express it physiologically, the presence of far more complicated sensation connections than the development of the direct orientation based upon a fixed hereditary mechanism, just as in general the most complicated instincts operate with a much lesser expenditure of neuron-complexes than do comparatively simple plastic performances. On the other hand the amount of nerve work sometimes actually involved in the case of indirect distance orientation is at times very great. For example, even such an enormously complicated succes-

[13] F. Santschi, "Comment s'Orientent les Fourmis," Rev. Suisse de Zoöl., 21, 1913.

[14] As in orientation by means of the sun, for instance.

sion of associated optical, kinetic, and acoustic engram-complexes as are involved in the daily course of business in a great city may run its course almost unconsciously after frequent repetition. This sort of secondary automatization of plastic engram complexes, which were originally highly conscious, is one of the most interesting phenomena in the biology of memory; it is based in the first instance upon the "Law of Ecphoria," according to which even a partial return of a small portion of that sensation complex which previously operated engraphically is sufficient to reactivate the entire successive associated engram-complex, since the successive ecphoria spreads automatically from one engram to another "as in a running fire."

We have thus come to the end of our theoretical observations. While these may seem to possess a somewhat abstract philosophical character they are by no means barren speculations. I expect to have an opportunity shortly to lay before you an account of certain practical experiments which involve the application of these laws. It must never be forgotten that here as elsewhere nature usually operates with manifold methods. . . .

[*Dr. Brun's second lecture, a most interesting one, dealing with his experiments on ants and their peculiar behavior under various conditions, will be published in the January issue of the* SCIENTIFIC AMERICAN MONTHLY.—EDITOR.]

Iron and Steel Manufacture in Japan

(*Continued from page* 369)

employers see fit to give them. Even the mechanics are undeveloped.

It must be remembered that the machinist trade is a comparatively new one in Japan; there is no local precedent to follow. Whatever the Japanese machinist has learned in the way of new things is from foreigners, and often he does not grasp the basic principle of an operation. He is imitative rather than creative; he is clever in this way, but could not be called ingenious or inventive. Saito Man, a prominent Japanese writer, himself admits that for 'energy or practical talents, the average Japanese cannot hold a candle to the American.'"

The Ikegai works has, along with other similar enterprises, had to contend not only with the natural ignorance of the laboring class, but also with the ignorance due to lack of opportunities to learn. So, then, the fact that they are forging ahead is to the credit of these concerns, and the spirits which are pushing them along. "The finished machines present a creditable appearance, everything considered, and to the layman might be of American make with the exception of the name-plate, for they are exact copies of American machines in some cases." All this means that there is so much to be learned quickly that the mind is exhausted with this phase of development to the exclusion of creative effort rather than that the Japanese mental equipment does not include a creditable order of inventive ability. Now and then, in Japan as elsewhere, some kindred spirit to Munesuké 2nd will kick himself loose from his environment and proceed to create something along a new line.

The Ikegai Iron Works, Ldt., has two foundries, employing altogether, say, 750 men. About 200 of these are engaged in molding. It seems that molding is no new trade in Japan. At least, it is much older than the trade of machinist. The son learns from the father, and in turn teaches his son—or, however the trade is acquired, it descends from father to son. This is something not unfamiliar to Europe. It is said that the molders at the Ikegai plants turn out some very good castings. Difficult core work seems beyond them at present. The molder gets 40 to 45 cents per day. No molding machines are in use, unless they have been very recently installed. A large part of the molding is done right on the floor. This is the case, even with small work. Apparently all the Japanese iron foundries use a sand found on the outskirts of the City of Tokyo. The pig iron comes largely from outside sources, of which China is the chief.

Japan has made a beginning in manufacturing electric equipment on its own soil. Motors, generators, and transformers are built on the spot. Thus, motor generators up to a capacity of 6,000 k.w. have been successfully built in Japan. Special parts have, in some cases, to be imported, and certain special types of machines must be built abroad. But even generators direct-coupled to water and steam turbines have been constructed in the Empire. There are one or two big factories which are more or less connected with big electric concerns in the Western world. Even so, the Japanese naturally do the work, and must assuredly do more or less work of a directive character. That is to say, even where foreign interests are operating in Japan, these factories may be regarded as schools for the Japanese.

The Empire of Japan issues patents to the resident and also to the non-resident. American machines not patented in Japan are liable not only to be copied, but to be locally patented in favor of a Japanese. The American inventor and manufacturer who expect to do business in Japan should be alert as to this matter.

Electrification of the Belgian Railways

BELGIUM is also engaged in working out schemes for the substitution of electric traction in place of steam on certain of her lines. Work is to be commenced in 1920. The first sections to be electrified will be Brussels-Antwerp and Brussels-Luxemburg, which will be followed by Brussels-Ostend. The journey from Brussels to Antwerp by electric train will occupy 25 minutes and trains will be run evrey 15 minutes.—Abstracted by *The Technical Review* from *La Nature*.

Experiment to Determine the Angle of Repose for Loose Materials

A CYLINDER 1.13 ft. diameter, 1 foot high, without ends, is placed on a smooth, level table, and filled with the material to be tested. It is then slowly and carefully lifted when part of the material will remain on the table in the shape of a cone, h feet high. The value of h is measured in feet, and $\sqrt{h^3} = \tan b$, when b is the angle formed by the sides of the cone with the level table, *viz.*, the angle of repose.

It will be found to vary with the temperature and the degree of moisture of the material tested. Angles given in text books apply only to average circumstances, and may be quite misleading under special conditions.—*Zeitschrift des Vereines Deutscher Ingenieure.*

Why the Castor-Oil Plant is called Palma Christi

THE war greatly stimulated the castor-oil industry in practically all countries where the plant producing the so-called beans or oil nuts can be made to grow successfully. While the name of the product of the seeds is castor oil, the plant itself is generally known as palma christi which means "palm or hand of Christ." There appears to be considerable speculation as to why the name "Palma Christi" was given to this plant. The supposition most often advanced, especially by those who are not familiar with the botanical affinities of this small shrub, is that the term signifies Christ's palm or the palm of Christ, palm having reference to a group of plants belonging to Lindley's palmal alliance of hypogynous endogens. There is, however, clearly no relation between a true palm and the Palma Christi plant which botanists call *Ricinus communis*, a member of spurge family of plants (*Euphorbiaceae*). The fruit is a three-lobed or segmented globular dry pod which is believed by some to have suggested the idea of three in one or unity in Christ. This theory could possibly be accepted and appropriately applied if the castor-oil plant had the slightest relation to the true palms, but this is not the case and has never been referred to as a pair in any language. A glance at the leaves of the castor oil plant, which are large, palhate, depely divided into seven lance-shaped segments, at once reminds one of the palm of the hand; just what the name "Christ" signified in this connection is more difficult to understand, but it is believed that it has reference to the virtues of the oil in the seeds. A mother noting that her child is becoming cross and irritable gives it a dose of castor oil and its disposition invariably mproves. Thus the large palmate-shaped leaves of this plant fancifully represent the hand of the great healer and teacher.

Posture as a Factor in the Origin of Animal Species

THE changes in attitude of animals usually enumerated have been susceptible of frequent repetition in various epochs in organisms of similar nature; they are more or less recent; and from this proceeds the gradation which enables us to arrange them in series, in the forms of the present day; they have been able to produce various secondary consequences according to circumstances; but the conviction which results from their comparison of these forms is that they were not imposed in the very beginning upon the organisms which exhibit them, but that the latter have had recourse to them under the pressure of circumstances in the conditions of the environment in which they live, or even merely because of a modification in their comparative specific gravity, so as to obtain a more commodious existence and assure themselves of the maximum amount of well-being. These changes were temporary at first, they then became distinctive, and finally hereditary.

Even in the ancestral series of animals of the present time it has been possible to produce many successive changes; each of these has left its trace, heredity must have preserved the phases, and hence we ought to be able to perceive these in the embryonic evolution of the types we are considering. This is just what happens, in fact, and is that which gives a definite significance to the information which this evolution furnishes as to their origin.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

Published by Scientific American Publishing Co.

New York, Saturday, December 20, 1919

Munn & Co., 233 Broadway, New York

Charles Allen Munn, President; Orson D. Munn, Treasurer
Allan C. Hoffman, Secretary, all at 233 Broadway

The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00
Scientific American (established 1845) 5.00
The combined subscription rates and rates to foreign countries including Canada, will be furnished upon application.
Remit by postal or express money order, bank draft or check.

Scientific American Publishing Co.
233 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

Back Numbers of the Scientific American Supplement

SUPPLEMENTS bearing a date earlier than January 1st, 1918, can be supplied by the H. W. Wilson Company, 958-964 University Ave., Bronx, New York, N. Y. Please order such back numbers from the Wilson Company. Supplements for January 1st, 1918, and subsequent issues can be supplied at 10 cents each by SCIENTIFIC AMERICAN PUBLISHING Co., 233 Broadway, New York.

WE wish to call attention to the fact that we are in a position to render competent services in every branch of patent or trade-mark work. Our staff is composed of mechanical, electrical and chemical experts, thoroughly trained to prepare and prosecute all patent applications, irrespective of the complex nature of the subject matter involved, or of the specialized, technical, or scientific knowledge required therefor.

We also have associates throughout the world, who assist in the prosecution of patent and trade-mark applications filed in all countries foreign to the United States.

MUNN & Co.
Patent Solicitors

Washington Office: 625 F St., N.W. | 233 Broadway New York, N. Y. | Chicago Office: 801 Tower Bldg.

Table of Contents

PAGE

The Sense of Direction in Animals.—By Dr. Rudolf Brun 362
Kudzu, the Latest Forage Plant.—By Robert H. Moulton.—Illustrated 364
Checking the Alignment of Diesel Engine Shafts.—By Geo. E. Windeler 365
A Method of Determining Wind Velocity and Direction in the Upper Air by Sound 365
The Texture of Sands—Illustrated 366
The Dynamical Theory of Electric Engines 366
Airplane Wing Design—Illustrated.—By Walter C. Durfee 367
Iron and Steel Manufacture in Japan—Illustrated.—By J. F. Springer 368
The Chlorination of Water—Illustrated.—By Abel Wolman and Linn Enslow 370
Latent Heat of Fusion.—By Prof. W. C. McC. Lewis . . . 371
Experimental Wireless Telegraphy and Telephony—XI—Illustrated.—By Louis Gerard Pacent and Austin C. Lescarbours 372
Physical Properties of Molybdenite 373
Future Internal Combustion Engines—II—Illustrated.—By Prof. C. A. Norman 374
Electrification of the Belgian Railways 376
Experiment to Determine the Angle of Repose for Loose Materials 376
Why the Castor-Oil Plant is Called Palma Christi 376
Posture as a Factor in the Origin of Animal Species 376

1919

them-
These
ecame

f the
many
trace,
hence
ryonic
s just
defi-
evolu-

AN

o.

aurer

$5.00
5.00
ntries
ck.

the
lished
pear
eflect
istry

uary
Com-
N. Y.
Com-
ubse-
n by
way,

in a
anch
osed
thor-
ap-
the
ical,

who
ap-
ilted

lice:
Bldg.

PAGE
362
364
365
365
366
366
367
368
370
371
372
373
374
376
376
376
376